CONNECTICUT RIVER FLOOD CONTROL PROJECT

NORTHAMPTON, MASS.

CONNECTICUT & MILL RIVERS, MASSACHUSETTS

ANALYSIS OF DESIGN FOR LOCAL PROTECTION WORKS

FISCAL YEAR 1939 SECTION, ITEM N.2
CONTRACT – STA. 0 TO HIGH GROUND
OVER RAILROAD AND HIGHWAY

APRIL 1939

CORPS OF ENGINEERS, U.S. ARMY

U.S. ENGINEER OFFICE PROVIDENCE, R.I.

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NORTHAMPTON DIKE

ANALYSIS OF DESIGN

CONTENTS

NORTHAMPTON DIKE

PERTINENT DATA

Location - Connecticut River, Northampton, Massachusetts.

Area Protected		0.46 sq.mi.
Limits of dike design and of contract	Sta. 0+00 to 36+00 Sta. 39+50 to 49+30	

Elevations (above mean sea level)

Top of dike (Sta. 0+00)	132.5
Top of dike (Sta. 30+00)	132.0
Top of dike (Sta. 49+30)	132.0

Embankment (Sta. 0+00 to 36+00 and Sta. 39+50 to 49+30)

Total length of dike on contract	4,580 ft.
Total impervious fill	42,800 cu.yds.
Total pervious and random fill	173,500 cu.yds.
Total sheet piling	9,200 sq. ft.
Total riprap (hand placed)	2,300 cu.yds.
Total gravel bedding	2,650 cu.yds.
Total topsoil	14,100 cu.yds.

I. INTRODUCTION

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A. AUTHORIZATION AND PAST REPORTS. - The Northampton dike project is authorized under the Flood Control Act approved June 28, 1938. It is a part of the Connecticut River flood control plan recommended by the District Engineer in "Report of Survey and Comprehensive Plan for Flood Control in the Connecticut River Valley," dated March 20, 1937, approved by the Chief of Engineers, November 29, 1937 and published as House Document No. 455, 75th Congress, 2nd Session.

B. BRIEF DESCRIPTION OF DIKE AND APPURTENANT STRUCTURES. - The "Fiscal Year 1939 Section" Item N 2 covered by this analysis will consist of an earth dike 4580± feet long between dike Stations 0+00 and 49+30 with a maximum height of 23 feet. There are two secondary road ramps over the dike; a Boston and Maine Railroad stop-log gate and United States No. 5 Highway stop-log gate. A section of dike across Mill River between Stations 36+00 and 39+50 will be omitted from construction for the present. The storm and sanitary sewage of the City of Northampton now empties into Mill River. The City proposes to construct an interceptor sewer in the bed of the Mill River. It will extend down Mill River, under the omitted dike section across Mill River and thence to the Connecticut River and will be approximately 9,000 feet long. Preliminary design of this sewer by the City of Northampton is in progress.

II. SELECTION OF SITE

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A. GENERAL LOCATION. - The "Fiscal Year 1939 Section" project is located in the southeast portion of the City of Northampton on an alluvial flood plain approximately 5,000 feet from the western edge of the Connecticut River channel in its normal stage height. The dike begins at the intersection of Pomeroy Terrace and Hancock Street and proceeds southeast across Meadow Street, thence southwest across Hockanum Road and Mill River to the Boston and Maine Railroad tracks and thence along the existing dike to high ground approximately 500 feet west of the intersection of United States No. 5 Highway and the existing dike.

B. ALINEMENT. - The alinement of the dike was determined with regard to the topography, protection afforded and by economic studies.

III. GEOLOGICAL INVESTIGATIONS

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A. NATURE OF VALLEY. - The dike is located over the middle portion of a broad, deeply buried pre-glacial rock valley. Glacial deposits extend into the valley on the west side, forming the relatively higher ground on which the City of Northampton is situated. The broad comparatively flat valley bottom lying to the east is the result both of river erosion and deposition. During the Glacial Period, the valley was transformed into an extensive glacial lake, in which large quantities of glacial silt were deposited. The lowest extent of this formation is not certain, but its occurrence at an elevation near sea level has been proven. Similar deposits occur, as erosional remnants, on the west side of the valley, well above the present valley floor. The Connecticut River during more recent geologic time has laterally extended its erosion of the valley until the present valley floor is about 2 miles wide. The river is now slightly entrenched in broad meanders, the banks of which are not sufficiently high to restrain the river during high water. As a result the stream periodically overflows its banks and deposits additional sediment on the flood plain.

B. METHOD AND EXTENT OF EXPLORATIONS. - Subsurface explorations were accomplished by means of wash borings, auger borings, and test pits. Investigations by wash borings, utilizing drive sampling methods were made to determine the character and thickness of overburden forming the dike foundations. Soil samples of 1-1/2 inch diameter were frequently obtained, in some cases continuously, by means of standard sampling equipment. In addition one larger boring was completed for the purpose of obtaining 4-7/8 inch diameter undisturbed samples. Another similar boring is now underway. These are outside the limits of this portion of the work and are for use in designing the diversion channel for Mill River. Auger borings and test pits were used for both foundation and borrow investigations. The location of foundation explorations is shown on Plate No. 2 titled "Subsurface Explorations" and the records are shown on Plate No. 3 titled "Record of Subsurface Explorations."

C. SITE. - The dike is located on the westerly side of the valley where the flood plain of the Connecticut River contacts moderately higher ground. The Mill River northwest of the proposed dike is fairly well entrenched in this higher ground. Downstream of this point, however, it is entrenched in its own flood plain deposit and those of the Connecticut River. Frequent floods have deposited alluvial sands and silts, forming a continuous fine textured soil mantle which covers the much older glacio-fluvial deposits. The constituents of this mantle generally vary in texture from medium and fine sand, adjacent to the Connecticut and Mill Rivers, to medium and fine silt, some distance back from the rivers.

The geologic section, shown on Plate No. 4 indicates a comparatively uniform distribution of alluvial and glacio-alluvial materials, throughout the foundations. Three distinct groupings of stratification are shown, the most prominently developed strata being the lowermost interbedded glacial silt and clay strata (chiefly Classes 10, 10C, 12 and 12C). The thickness of this formation is great, as proven by two bore holes, one of which was carried into the deposit for a depth exceeding 65 feet without radical change of material. This formation is unquestionably of glacial origin, conforming in all respects to the characteristics of a glacial lake deposit. Sand strata are prominently developed between the alluvial silts (Classes 8, 10, 11, and 13) previously mentioned, and the extensive glacial silt strata. Fine sand (Class 6) lies immediately below the flood plain silts and immediately above medium and coarse sand and gravel (Classes 2, 4, and 5). The fill section shown extending from the right bank of the Mill River to the end of the proposed construction is a previously constructed earth embankment. The foundation conditions in this stretch are similar to those elsewhere.

D. NATURE OF EXCAVATIONS. - Excavations, exclusive of those required for embankment materials, will be made for toe trenches and for stripping of topsoil throughout the foundation area. Additional excavations will be required for footings at stop-log structures. Flood plain silts (Classes 8, 10, and 11) will be removed to an average depth of 5 feet in the construction of the inspection trench and impervious toe. Excavations for the landside toe drains will be made in similar materials, the depth of cut varying from about 2 feet to 6 feet. One stop-log structure will be located in an old railroad embankment, and another in a highway embankment. Investigations indicate that required excavations for these structures will be made in several types of granular material ranging from Class 2 to Class 9.

E. SUBSURFACE LEAKAGE. - The wide flood plain extending between the dike and the Connecticut River, forming a relatively impervious natural blanket of Classes 8, 10, and 11, will prevent any marked seepage through the foundations. This condition is sure to hold even though the pervious formations, beneath this natural blanket, extend to the Connecticut River and contact the coarser river sediments. Breaks in the natural impervious blanket, due to erosion during floods, have been noticed. However, these do not occur close enough to the dike to seriously affect the seepage path in the foundation. Seepage passing through the natural blanket on the riverside before emergence will be forced to break through a similar blanket on the landside. In the immediate vicinity of the dike such seepage will be intercepted by the rock toe drain. Foundation treatment to prevent subsurface leakage in the section adjacent to the Mill River is not a part of the work proposed here.

IV. HYDRAULIC DESIGN

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A. DESIGN FLOOD. - The design flood on which the dike grade is based, is the maximum predicted flood reduced by the 20 reservoirs included in the Comprehensive Plan. The determination of the maximum predicted flood is discussed on Appendix 1 of "The Report of Survey and Comprehensive Plan for the Connecticut River" dated March 20, 1937. It has a peak discharge at Northampton of 304,000 c.f.s., approximately 20 per cent greater than the maximum flood of record. The following table lists the adopted grades for the top of the earth dike.

DESIGN GRADES

Location	Dike Type	Report Station	New Dike Station	Dike Grade
High ground, Pomeroy Terrace	Earth	0+60	0+00	132.5
North of Hockanum Road	"	28+65	30+00	132.0
High ground, end of existing dike	"	128+22	49+30	132.0

Note: Earth dike grade varies uniformly between dike stations 0+00 and 30+00

B. FREEBOARD. - The freeboard for the earth dike is 5 feet and for concrete walls, 3 feet, as recommended by the Board of Engineers for Rivers and Harbors.

C. LOCAL CONDITIONS. - During flood periods the Connecticut River, in addition to its main channel, flows over the local flood plain. The ground elevations of this flood plain vary from approximately 110.0 to 118.0 mean sea level. During the major flood of 1936, the elevation of the flood water was about 129.4 mean sea level, which overtopped an existing dike by about 5 feet. The effect of the proposed dikes in raising the water surface elevation during floods will be negligible since the dikes encroach but slightly on the flood plain.

V. LABORATORY AND FIELD INVESTIGATION OF SOILS

V. LABORATORY AND FIELD INVESTIGATION OF SOILS

A. CLASSIFICATION OF MATERIALS. - Soils, based on grain sizes, have been classified into 16 classes and are shown graphically on Plate No. 7 and described in Table No. 1 on the following page. Soils of uniform texture are designated by even numbers, soils of variable texture by odd numbers and grain sizes of materials follow the M. I. T. classification except that the size demarcation between silt and coarse clay is not 0.002 mm. but varies from 0.006 mm. to 0.0006 mm.

B. GRAIN SIZE ANALYSIS. - Grain size curves of samples have been obtained from sieve and hydrometer analysis and the soil classified. Sedimentary units of soil were grouped and drawn up as shown on Plate No. 4 titled "Geologic Section."

C. WATER CONTENT AND VOID RATIO. - The water content and void ratio of the materials in its natural state from the proposed dike foundations and borrow areas have been determined.

D. PERMEABILITIES. - Permeability values have been determined for each class of overburden material and the range limits have been tabulated in Table No. 2 on page 10.

PROVIDENCE SOIL CLASSIFICATION
U.S. ENGINEER OFFICE
PROVIDENCE, R.I.

TABLE NO. 1

CLASS	DESCRIPTION OF MATERIAL
1	Clean Gravel. - Contains little coarse to medium sand.
2	Uniform Coarse to Medium Sand. - Contains little gravel and fine sand.
3	Variable - Graded from Gravel to Medium Sand. - Contains little fine sand.
4	Uniform Medium to Fine Sand. - Contains little coarse sand and coarse silt.
5	Variable - Graded from Gravel to Fine Sand. - Contains little coarse silt.
6	Uniform Fine Sand to Coarse Silt. - Contains little medium sand and medium silt.
7	Variable - Graded from Gravel to Coarse Silt. - Contains little medium silt.
8	Uniform Coarse to Medium Silt. - Contains little fine sand and fine silt.
9	Variable - Graded from Gravel to Medium Silt. - Contains little fine silt.
10	Uniform Medium to Fine Silt. - Contains little coarse silt and coarse clay. Possesses behavior characteristics of silt.
10 C	Uniform Medium Silt to Coarse Clay. - Contains little coarse silt and medium clay. Possesses behavior characteristics of clay.
11	Variable - Graded from Gravel or Coarse Sand to Fine Silt. Contains little coarse clay.
12	Uniform Fine Silt to Medium Clay. - Contains little medium silt and fine clay (colloids). Possesses behavior characteristics of silt.
12 C	Uniform Clay. - Contains little silt. Possesses behavior characteristics of clay.
13	Variable - Graded from Coarse Sand to Clay. - Contains little fine clay (colloids). Possesses behavior characteristics of silt.
13 C	Variable Clay. - Graded from sand to fine clay (colloids). Possesses behavior characteristics of clay.

TABLE NO. 2

General Type	Class	Coefficient of Permeability k x 10-4 cm./sec.	Coefficient of Permeability k x 10-4 ft./min.
Uniform	2	120 to 400	240 to 800
	4	20 to 120	40 to 240
	6	5 to 20	10 to 40
	8	1 to 5	2 to 10
	10 or 10C	0.1 to 1	0.2 to 2
	12 or 12C	Less than 0.1	Less than 0.2
Variable	1	Greater than 1000	Greater than 2000
	3	200 to 1000	400 to 2000
	5	50 to 200	100 to 400
	7	15 to 50	30 to 100
	9	3 to 15	6 to 30
	11	0.2 to 3	0.4 to 6
	13 or 13C	Less than 0.2	Less than 0.4

E. SHEAR AND COHESION. - Shear tests have been made on materials from the proposed dike foundations and on borrow area materials for use in the pervious and impervious sections of the dike.

F. COMPACTION. - Compaction tests based on the Proctor analysis procedure have been made on pervious and impervious embankment materials. The results have been tabulated and are shown on Plate No. 8.

G. COMPRESSIBILITY. - There will be but little settlement and no lateral displacement under the dike.

H. OTHER TESTS. - Other tests include Atterberg limits, extraction of solubility and specific gravity.

J. BORROW AREAS. - Providing materials of suitable quality for embankment construction, within economic hauling distance, has been a major difficulty. The typical embankment section shown on Plate No. 11 is a direct result of geological conditions. Pervious materials near the site occur at a prohibitive depth, generally below the water table. Impervious materials are abundantly developed in glacial deposits in the higher grounds flanking the west side of the valley. Similarly, impervious materials of river origin occur in a widespread formation in the upper part of the valley overburden. These impervious materials have a natural water content which, from a workability standpoint, prohibits their use unless absolutely necessary. Near the Connecticut and Mill Rivers, however, the upper portion of the valley overburden is predominantly a fine sand. The bulk of this material is not sufficiently impervious for use in impervious blanket construction. Also, it is not sufficiently free draining for use in pervious embankment construction. As a result of these geologic conditions, the standard typical dike section adopted in the Providence District, has been modified to include three embankment units (impervious blanket, pervious section and random fill) instead of only two units (impervious and pervious). Utilizing materials, available from areas near the dike, will contribute towards more economical construction.

Selection of the three borrow areas J, K. and M_2, shown on Plate No. 5 entitled "Borrow Areas" is based on extensive field and laboratory investigations. The permissible source of pervious materials is Borrow Area K. The deposits in this area, located at a distance of about 3 miles, are composed predominantly of sand (chiefly Class 2). A large supply is available.

Borrow Area M_2, the only source for random embankment materials and also a principal source of impervious materials, is located at a distance of about 0.9 miles. From an economic point of view it is desirable to obtain all of the impervious materials from this area. The overburden to a depth of about 8.5 feet is composed of two types (1) a fine sand containing coarse to medium silt, and (2) a fine sand with less silt, grading to a medium sand. The distinction between these two is not readily apparent unless such distinction is based on grain size analyses and inspection. In the Providence Soil Classification the former soil is classed as a Class 6-8, meaning that the lower part of the grain size curve is in the Class 8 range, while the upper part is in the Class 6 range. Incidentally, this soil is considered to be the coarsest tolerable limit of suitable impervious material. The other type of material, intended for use in random embankment construction, ranges between Class 6 and Class 6-4. The more impervious type occurs in the uppermost portions of the overburden, between average depths of 0.5 feet and 3.0 feet.

The ratio of occurrence within Area M_2 of Class 6-8 and better material to Classes 6 and 6-4 is about 3 to 8.*

The natural moisture contents of random materials, due to their coarse texture, do not present much of a construction problem. The types intended for impervious blanket construction, however, have a moisture content slightly above that necessary for satisfactory compaction. If high water should flood the borrow area some time during construction, resulting in even higher moisture contents, difficulty may be experienced in placing impervious materials and obtaining the desired compaction. For such a contingency another source of impervious materials, Borrow Area J, located at a distance of 2.7 miles, is being made available. The deposit consists essentially of interstratified Classes 8, 10, and 12 which occur beneath an overburden varying in thickness from 1 foot to 7 feet. This overburden is suitable for random embankment construction but, due to large available random materials in Area M_2, will be spoiled at the pit.

Mechanical analysis curves of typical samples of materials encountered in the proposed borrow areas are shown on Plate No. 6. Amounts of materials available and their suitability are summarized in Table No. 3.

*It is intended to exercise close supervision and inspection in the borrow pit for properly selecting impervious and random materials.

TABLE NO. 3

BORROW MATERIALS AVAILABLE

Borrow Area	Occurrence	Volume Available cu.yds.	Volume Required cu.yds.	Intended Use	Test Data Indicating Suitability: Classification	Water Content: Natural	Water Content: Optimum	Permeability $k \times 10^{-4}$ cm/sec.	Remarks
J	Varies-average between depth of 4 ft. and 18 ft.	34,000	(A)	Impervious Blanket	Inter-stratified Classes 8, 10, and 12	33%	23.6%	0.1 - 1.0	Spoiling of 8500 cu. yds. over-burden necessary
K	Varies-average between depth of 1.3 ft. and 23.0 ft.	65,000+	42,600	Pervious Section	Class 2	5.5%	None	120 - 400	
M_2	Varies-average between depth of 0.5 ft. and 3.0 ft.	31,000+ (B)	(A)	Impervious Blanket	Class 6-8	22% (av.)	15.4%	2 - 10	
M_2	Varies-average between depth of 3.0 ft. and 8.5 ft.	81,500+ (B)	130,200	Random Section	Class 6 and 6-4	17% (av.)	14.2%	5 - 20	

(A) - Total volume of impervious required - 42,800 cu. yds.

(B) - Additional quantity available in immediately adjacent areas.

VI. DIKE DESIGN CRITERIA AND GENERAL DESIGN

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The Northampton embankment section calls for a large section of random material to be covered on the riverside by a blanket of impervious material, and on the landside by a section of pervious free-draining material. General design criteria for the Northampton Dike include safety, stability and reduction of seepage and are as follows:

(1) The crest of the dike is at such a grade that overtopping at design flood and by wave action is eliminated.

(2) a. The slopes of the dike are such that they will be stable under all conditions.

b. For the Northampton dike sections between 10 to 20 feet in height a waterside slope of 1 on 3 and a landside slope of 1 on 2-1/2 are required. The slopes for dike sections greater than 20 feet in height are 1 on 3 for both sides. After a study of the flow of flood waters in the river, 12-inch hand placed riprap over a 6-inch gravel bed was required over critical areas to prevent scour.

(3) a. The line of saturation is well within the landside toe.

b. The dike is designed for a fairly low line of saturation and analysing the Northampton dike sections, the flood water will seep very slowly through the impervious blanket of low permeability to the random and pervious sections where, because of a somewhat greater permeability, together with the influence of the rock toe drain, the line of saturation will drop below the landside toe.

(4) Seepage and surface run-off behind the dike are collected by the rock toe drain and existing catch basins. Since the dike throughout

is founded on soil, seepage through the foundation will not be excessive owing to the 5-foot depth cut-off of impervious material and to natural foundation soil materials of low permeability. Such seepage through the foundation or dike as may occur will have a very low velocity and will be collected by the rock toe drain. The rock toe drain is connected to existing sewers which in turn will empty into the intercepting sewer which the City of Northampton proposes to construct in the bed of Mill River. (See Paragraph Section I B.) Future construction calls for the erection of a pumping station, which will force the discharge of the interceptor sewer during flood periods through a concrete conduit under the omitted section of the dike, between Stations 36+00 and 39+50.

(5) There is no possibility for free passage of water from riverside to the landside. All pipes, conduits, etc. are either removed from under the dike or encircled with seep rings to prevent free seepage along their surfaces.

(6) No material soluble in water is used in any part of the dike and soils laboratory tests have been made of borrow area materials for solubility. (See Paragraph V H.)

(7) The foundation under the dike is sufficiently stable to resist stresses due to the embankment load. (See Paragraph V G.)

(8) Where the dike crosses existing roads, ramps of adequate widths and proper grades are provided for traffic over the dike. The ramps which are nearly perpendicular to the center line of the dike, will be built of random material with cross-sectional slopes of 1 on 1-1/2 on the landside of the dike and, because of the saturated condition of the riverside ramp immediately following floods, with cross-sectional slopes of 1 on 2.

VII. STRUCTURAL DESIGN

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A. GENERAL. - Included in the Fiscal Year 1939 Section of the Northampton Dike are two reinforced concrete stop-log structures, one to permit the Boston and Maine Railroad to pass through the dike at Station 42+41±, and the other to allow the passage of United States Highway No. 5 through the dike at Station 44+55±. Each structure consists of two retaining walls, placed parallel to the direction of travel, and a barrier of stop-logs supported in vertical grooves in the faces of the retaining walls.

The retaining walls are of two types, dependent upon their height. The shorter (highway) is of the cantilever type, the higher (railroad) of the counterfort type. Three seep rings are provided on the dikeside of each wall to prevent excessive seepage or piping along the face of the concrete.

The clear distance between faces of the retaining walls is too great to permit the use of single span logs of a practicable size. A center support (or supports) in the form of a detachable bracket on "A" frame is provided which reduces the barrier to two simple beams for the railroad crossing; two frames will be used for the highway crossing. This reduces the depth and length of the logs to a size which can be handled easily. These supports are built of structural steel members and each has its own concrete foundation.

A concrete cap for the sheet piling forms the sill upon which the lowest logs rest, providing a joint between logs and base comparable to the joint between logs. In the case of the highway structure, the entire width of the sill is made level with the highway surface.

For the railroad structure, a width of concrete equal to the width of the logs is brought to an elevation two (2") inches below the base of rail, and the remaining width of sill is twenty (20") inches below base of rail, to allow sufficient ballast to reduce impact stresses. In time of flood, the rails and ballast will be removed to permit placing the bottom log directly on the sill.

The principal load upon the retaining wall is the horizontal earth pressure when the river is down; that upon the barrier is the horizontal water pressure in time of flood.

For complete details concerning the Boston and Maine Railroad Stop-Log Structure see Plate No. 14.

For complete details concerning the United States Highway No. 5 Stop-Log Structure see Plate No. 15.

B. SPECIFICATIONS FOR STRUCTURAL DESIGN

(1) General. - The structural design of the flood wall has been executed, in general, in accordance with standard practice. The specifications which follow cover the conditions affecting the design for stability and for reinforced concrete.

(2) Unit Weights. - The following unit weights for materials were assumed in the design of the structure:

Water	62.5	pounds	per	cubic	foot
Dry earth	100	"	"	"	"
Saturated earth	125	"	"	"	"
Concrete	150	"	"	"	"
Steel	490	"	"	"	"
Timber	50	"	"	"	"

(3) Earth pressures. - In computing active earth pressures, equivalent fluid pressures computed by the use of Rankine's formula were

used. They are as follows:

Earth, dry, equivalent liquid loading = 35 pounds per cubic foot.
Earth, saturated, " " " = 80 " " " "

In computing passive resistances, Rankine's formula was used with the coefficient of internal friction = 30 degrees.

(4) Hydrostatic Uplift. - Hydrostatic uplift on the base has been assumed as uniform over the entire base and equal to the elevation of tailwater above the base.

(5) Overturning. - The resultant of all external loads, including hydrostatic uplift and excluding base pressure, shall fall within the middle third for all loading conditions.

(6) Sliding. - The total horizontal forces due to external loads shall not exceed the resistance available from friction and passive resistance. The coefficient of friction to be used in such computations is 0.45.

(7) Bearing. - The total bearing pressure, equal to the sum of hydrostatic pressure plus the remaining effective base pressure, shall not exceed the maximum allowable base pressure of 4,000 pounds per square foot which was determined by the District Soils Laboratory.

(8) Frost Cover. - All footing bases shall lie at least 4 feet beneath the surface of the ground to avoid heaving by frost action.

(9) Path of Creep. - When using a sheet pile cut-off without a filter, the minimum path of creep shall be five (5) times the difference in elevation of headwater and tailwater. The path of creep is defined as the perimeter of the structure lying below and between the earth surfaces on the two sides of the wall.

(10) Reinforced Concrete. - In general, the design of the reinforced concrete was in accordance with the recommendations of the Joint Committee and the American Concrete Institute. Specifically, the working stresses are as follows:

a. Ultimate Strength. - The allowable working stresses in concrete are based on an average ultimate compressive strength of 3,400 pounds per square inch in 28 days.

b. Flexure. - Extreme fiber stress in compression = 800 pounds per square inch.

c. Shear.

Without special anchorage = 60 pounds per square inch.
With special anchorage = 90 " " " "

d. Bond.

Without special anchorage = 100 pounds per square inch.
With special anchorage = 200 " " " "

e. Embedment.

Minimum embedment to develop bond = 40 diameters.

f. Ratio of Moduli of Elasticity.

$E_s/E_c = n = 12$

g. Protective Concrete Covering.

In lower face of footings = 4 inches.
Other than in lower face of footings = 3 inches.

h. Temperature Steel. - Minimum steel in any exposed face is 5/8"Ø bars spaced one foot on centers.

(11) Reinforcing Steel. - The steel assumed to be used is new billet steel, intermediate grade, deformed bars. The effective cross-sectional areas are taken as net, and the working stress used is as follows:

Tension, main steel = 18,000 pounds per square inch.

(12) Structural Steel. - The design of the steel structures has been governed by the Standard Specifications for Steel Construction of the American Institute of Steel Construction. Maximum allowable unit working stresses are as follows:

a. Flexure (tension or compression) = 18,000 pounds per square inch.

b. Shear = 12,000 pounds per square inch.

(13) Timber. - The structural timber to be used is select White Oak, surfaced four sides, and creosoted. The maximum allowable working stresses used are high, due to intermittent use and to the probability of support by sandbags. They are as follows:

a. Flexure (tension or compression) 1,750 pounds per square inch.

b. Shear (parallel to grain) 156 pounds per square inch.

c. Bearing (perpendicular to grain) 265 pounds per square inch.

C. BASIC ASSUMPTIONS FOR DESIGN.

(1) Loadings. - In general, each member is to be designed to resist the most unfavorable combination of loadings in every direction. The assumed river high water elevation is 132.0; that of the tailwater 124.0. The crest of the dike is at elevation 132.0 with a berm of 10 feet. The riverside slope is 1 vertical to 2.5 horizontal, the landside slope 1 vertical to 2 horizontal. The principal load on the walls is due to active earth pressure and the secondary load is due to the pressure of the water on the stop-log barrier.

(2) Highway Structure. - The stem and base of the highway stop-log walls were designed as simple cantilever beams fixed at the

intersection of wall and base. The principal load on the vertical stem is the horizontal pressure from the earth dike and the principal load on the base slab is the difference between the weights acting down and the hydrostatic and bearing pressures acting up.

(3) Railroad Structure.

a. Structural Action. - Advantage was taken of the seep rings by reinforcing them to act as counterforts. The slabs between seep rings were designed by assuming beam action between the counterforts and reinforcing as such. The restraint offered by the sheet piling to both horizontal and vertical loads is neglected, as is the thrust which can be developed in the sill to resist overturning of the walls by earth pressures. The stability of the walls as a whole is analyzed, due to the irregularity of their shape.

b. Wall Stem. - The stem is designed to carry the differential load due to earth pressure to the counterforts by beam action. The effect of continuity and restraint is represented by an arbitrary increase of the maximum moment to $wL2/10$ in the center spans. The end spans are considered as cantilevers whose load is distributed in part to the base and in part to the counterfort.

c. Base Slab. - The load on the base is the difference between the weights down and the bearing pressures up. The design of the dikeside of the base is similar to that of the walls. The railroad side of the base is designed as a simple cantilever supported at the wall.

d. Seep Rings. - Sufficient reinforcing steel is placed in the seep rings to carry the tensile load transferred to them by the walls.

(4) <u>Stop-Logs</u>. - The load on the stop-logs is due to the head of the river water. They are designed as simple beams supported at the wall by a special groove and at the other support by a steel bracket.

(5) <u>Bracket</u>. - The load on the bracket is transferred to it by the stop-log barrier. The bracket itself is designed as an "A" frame, to resist the direct load and the overturning moment. The bracket is so connected that its parts can be easily handled and quickly set in place. Hoists are provided to facilitate the handling of the stop-logs.

VIII. CONSTRUCTION PROCEDURE

VIII. CONSTRUCTION PROCEDURE

A. FIELD OPERATIONS. - Assuming that the contract for the work will be let on or before May 20, 1939, and construction will commence on June 1st, it is contemplated that the work will be completed by December 10, 1939 in one construction season.

The following tabulation presents a proposed time limit of operations:

CONSTRUCTION PROGRAM

Designation	Quantity	Time Limit of Operations (Calendar Year 1939)	No. of Working Days	Daily Rate of Construction
Preparation of site		June 1-June 15	10	--
Excavation	15,000 c.y.	June 5-Aug. 5	40	374 c.y.
Placing of steel sheet piling	9,200 s.f.	June 20-July 20	20	460 s.f.
Placing of embankment	217,000 c.y.	June 20-Nov.20	100	2,170 c.y.
Concrete in stop-log structure	441 c.y.	June 30 - September 1	40	10 c.y.
Riprap	2,300 c.y.	Aug.20-Nov. 20	60	40 c.y.
Placing of topsoil	14,100 c.y.	July 20-Nov.20	80	160 c.y.
Placing of gravel bedding	2,650 c.y.	July 20-Nov.20	80	35 c.y.

B. INSPECTION AND TESTS. - The usual field inspection of all portions of the construction work will be made. Progress reports including log of work accomplished and of the number of workers on the job will be kept.

Field and laboratory tests of embankment materials, concrete and other materials will be made in order to control the quality of the work.

IX. SUMMARY OF COSTS

IX. SUMMARY OF COSTS

The total estimated construction cost of the Northampton Dike is $224,000, including 10% for contingencies and 15% for engineering and overhead, and is distributed as follows:

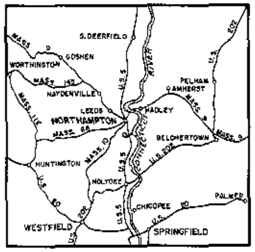
a.	Embankment	$154,700
b.	Reinforced Concrete	11,500
c.	Drainage	11,400
d.	Steel sheet piling	22,500
e.	Riprap, hand placed	21,000
f.	Miscellaneous	2,900
	Total	$224,000

X. PLATES

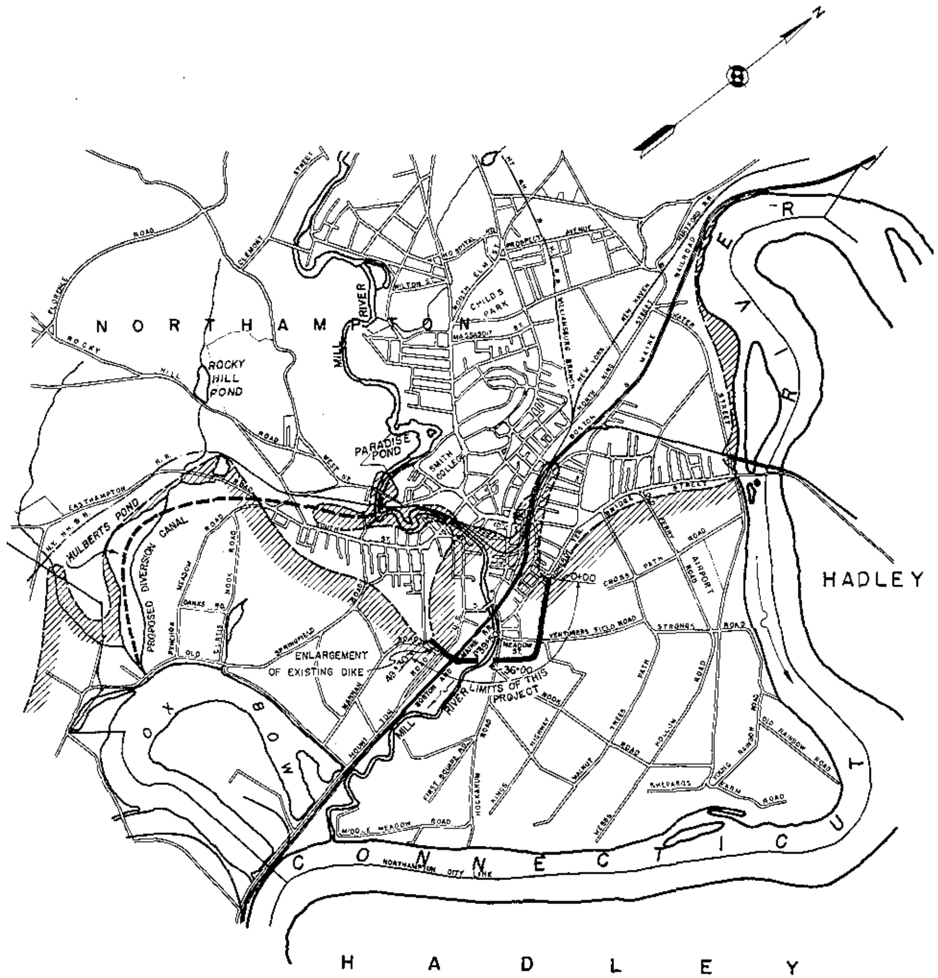
X. LIST OF PLATES

WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. ARMY



LOCATION MAP



VICINITY MAP

SCALE: 1" = 1600'

LEGEND

Proposed Project
Future Construction
Overflow Limits of the March 1936 Flood

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

FISCAL YEAR 1939 SECTION

PROJECT LOCATION AND INDEX

CONNECTICUT & MILL RIVERS — MASSACHUSETTS

IN 21 SHEETS — SCALE: 1 IN. = 1600 FT. — SHEET NO. 1

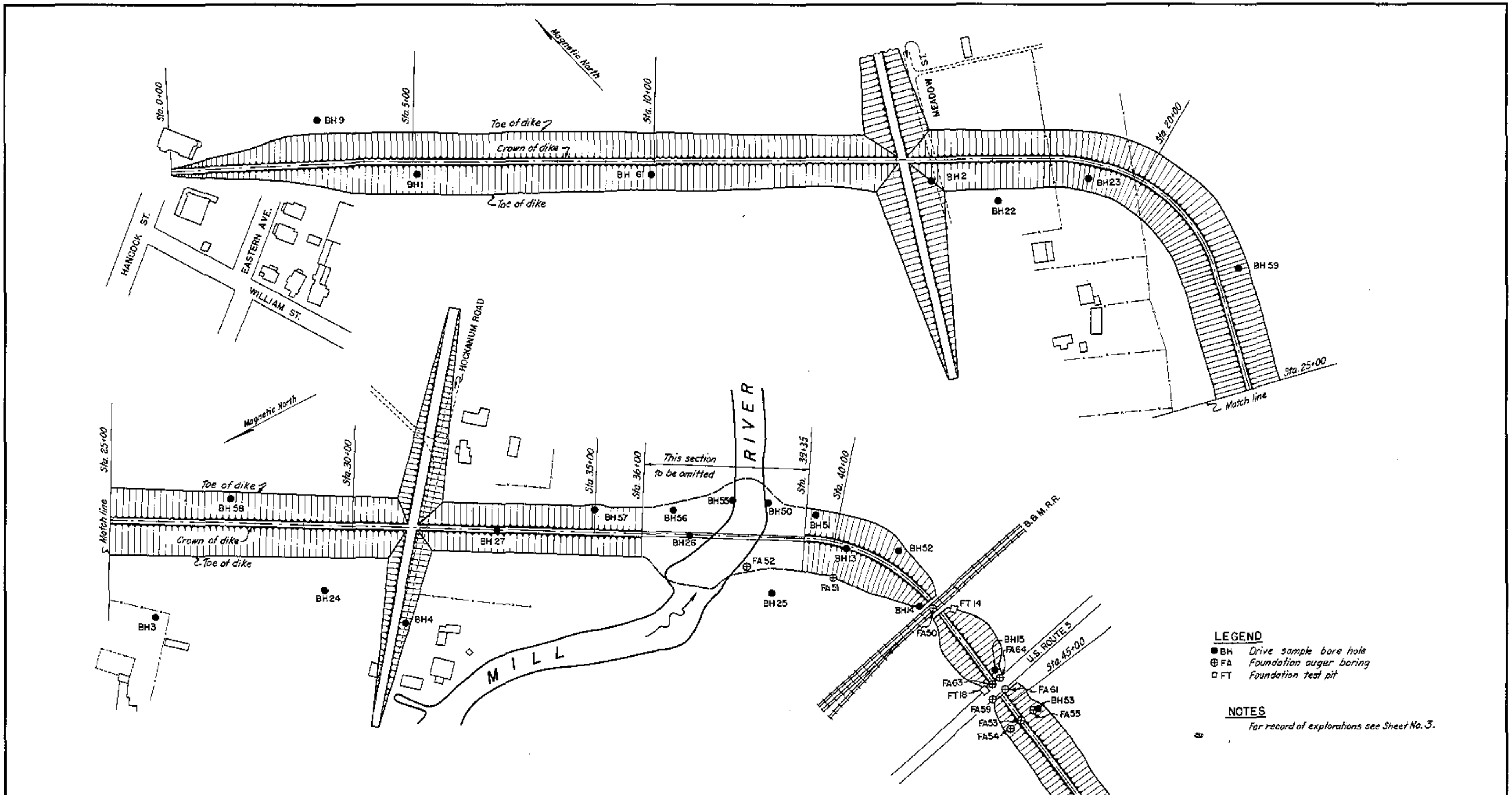
U.S. ENGINEER OFFICE, PROVIDENCE, R.I., APRIL 1939

FILE NO. CT-4-1391

PLATE NO. 1

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY



LEGEND
- ● BH Drive sample bore hole
- ⊕ FA Foundation auger boring
- ▫ FT Foundation test pit

NOTES

For record of explorations see Sheet No. 3.

DATE	REVISION	REV. BY	CK. BY	AP. BY

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

FISCAL YEAR 1939 SECTION

SUBSURFACE EXPLORATION

CONNECTICUT & MILL RIVERS — MASSACHUSETTS

IN 21 SHEETS — SCALE: 1 IN. = 100 FT. — SHEET NO. 2

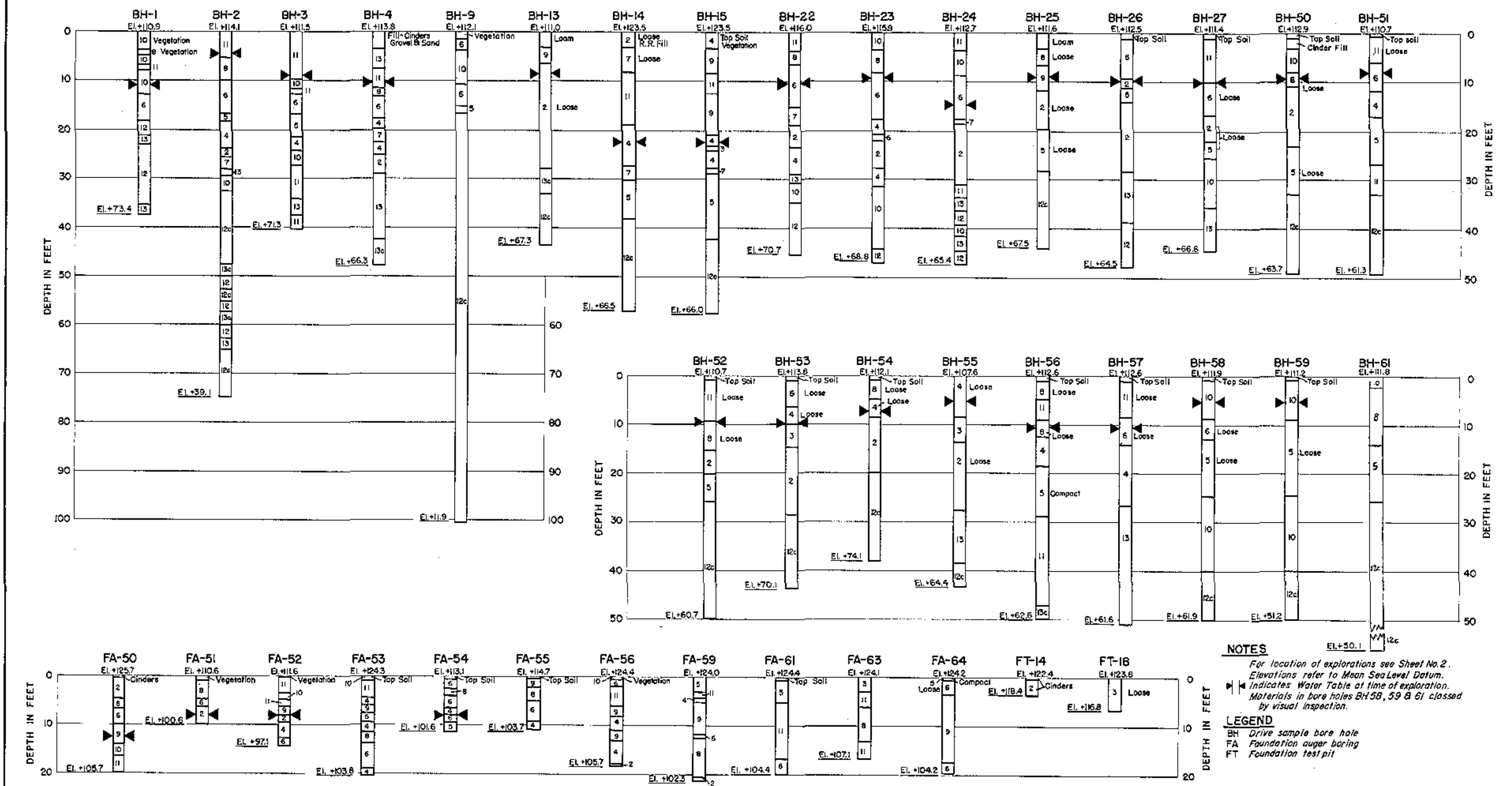
U. S. ENGINEER OFFICE, PROVIDENCE, R. I. — APRIL 1939

SUBMITTED: Senior Geologist, Head, Geology Section — APPROVAL RECOMMENDED: Principal Engineer, Chief F. C. Engineering Div. — APPROVED: Lt. Col., Corps of Engineers, District Engineer

COMPILED: Asst. Engineer — DRAWN: W.F.S. TRACED: W.A.T. CHECKED: F. H. A.

FILE NO. CT-2-1154

PLATE NO. 2



NOTES

For location of explorations see Sheet No. 2.
Elevations refer to Mean Sea Level Datum.
▶| |◀ *Indicates Water Table at time of exploration.*
Materials in bore holes BH 58, 59 & 61 classed by visual inspection.

LEGEND

BH *Drive sample bore hole*
FA *Foundation auger boring*
FT *Foundation test pit*

DESCRIPTION OF NUMERICAL CLASSES

1 Clean Gravel – Contains little coarse to medium sand.

2 Uniform Coarse to Medium Sand – Contains little gravel and fine sand.

3 Variable - Graded from Gravel to Medium Sand – Contains little fine sand

4 Uniform Medium to Fine Sand – Contains little coarse sand and coarse silt.

5 Variable - Graded from Gravel to Fine Sand – Contains little coarse silt.

6 Uniform Fine Sand to Coarse Silt – Contains little medium sand and medium silt.

7 Variable - Graded from Gravel to Coarse Silt – Contains little medium silt.

8 Uniform Coarse to Medium Silt – Contains little fine sand and fine silt.

9 Variable - Graded from Gravel to Medium Silt – Contains little fine silt.

10 Uniform Medium to Fine Silt – Contains little coarse silt and coarse clay. Possesses behavior characteristics of silt.

10C Uniform Medium Silt to Coarse Clay – Contains little coarse silt and medium clay. Possesses behavior characteristics of clay.

11 Variable – Graded from Gravel or Coarse Sand to Fine Silt – Contains little coarse clay.

12 Uniform Fine Silt to Medium Clay – Contains little medium silt and fine clay (colloids). Possesses behavior characteristics of silt.

12C Uniform Clay – Contains little silt. Possesses behavior characteristics of clay.

13 Variable - Graded from Coarse Sand to Clay – Contains little fine clay (colloids). Possesses behavior characteristics of silt.

13C Variable Clay – Graded from sand to fine clay (colloids) Possesses behavior characteristics of clay.

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

FISCAL YEAR 1939 SECTION

RECORD OF SUBSURFACE EXPLORATION

CONNECTICUT & MILL RIVERS — MASSACHUSETTS

IN 21 SHEETS — VERTICAL SCALE 1 IN. = 10 FT. — SHEET NO. 3

U. S. ENGINEER OFFICE, PROVIDENCE, R. I., APRIL 1939

SUBMITTED:	APPROVAL RECOMMENDED:	APPROVED:
SENIOR GEOLOGIST HEAD, GEOLOGY SECTION	PRINCIPAL ENGINEER CHIEF F. C. ENGINEERING DIV.	COL., CORPS OF ENGINEERS DISTRICT ENGINEER
COMPILED: ASST. ENGINEER	DRAWN: E.F.L. TRACED: N.M.V. CHECKED: T.H.S.	FILE NO. CT-2-1155

PLATE NO. 3

WAR DEPARTMENT CORPS OF ENGINEERS, U. S. ARMY

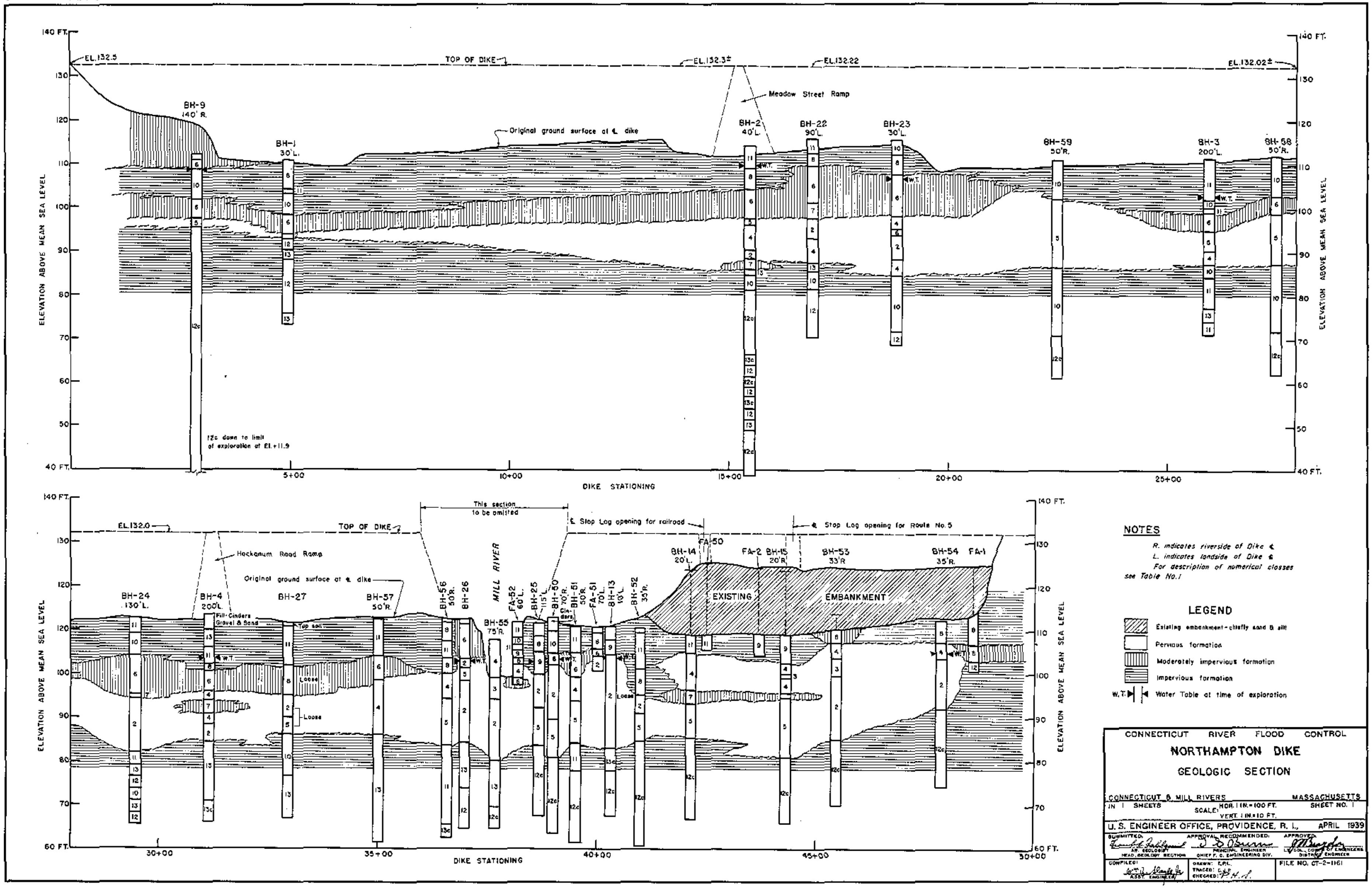
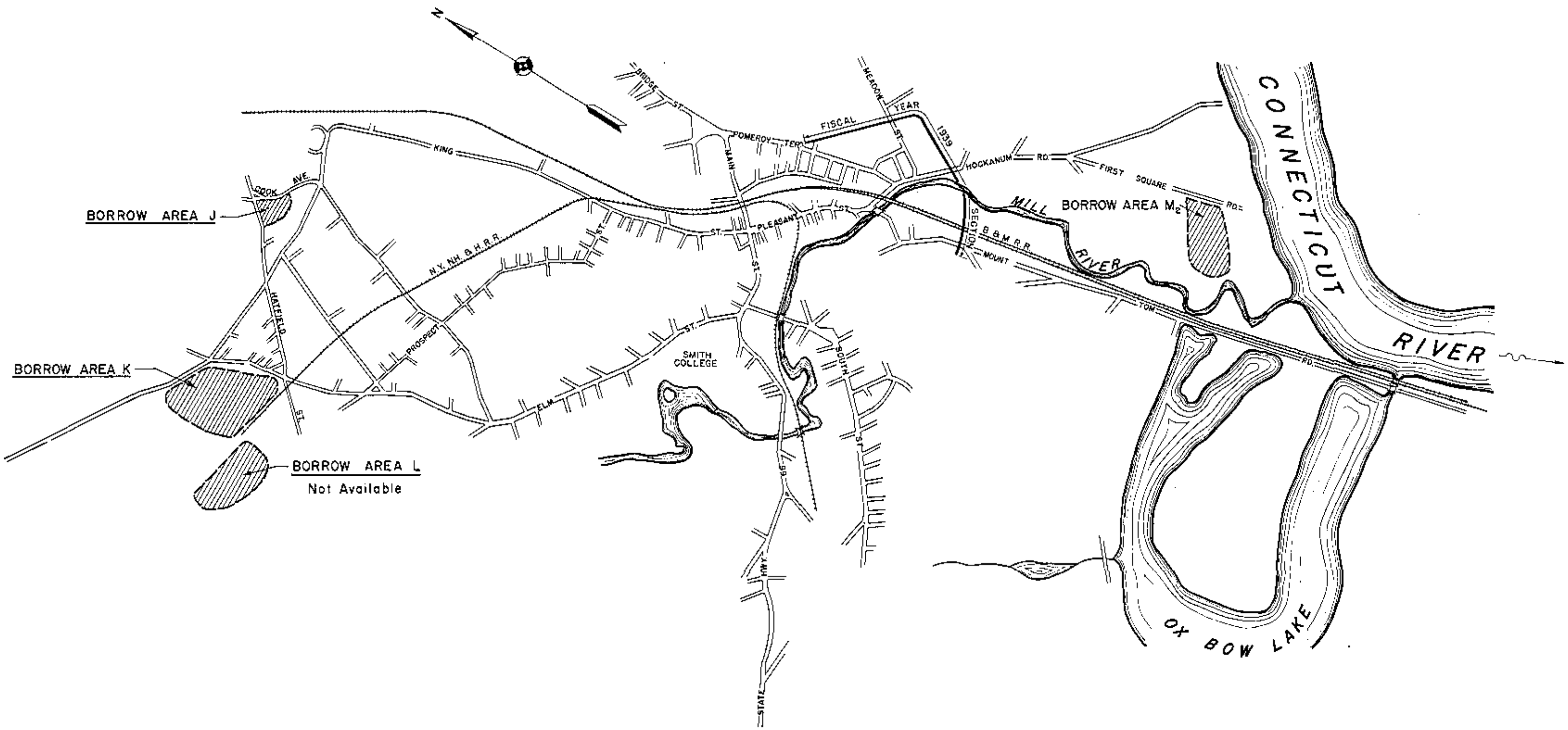


PLATE NO. 4

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY



BORROW AREA J	BORROW AREA K	BORROW AREA L	BORROW AREA M_2
Permissible borrow area for impervious embankment material, composed chiefly of medium and fine silt and minor amounts of clay overlain by unsuitable sand formation ranging from 1 foot to 7 feet in thickness. Natural moisture content of silt deposit varies. Content of some portions above that necessary for satisfactory compaction.	*Permissible borrow area for pervious embankment materials. Composed chiefly of coarse and medium sand with minor amounts of gravel and some fine sand. Area is wooded.*	*Permissible borrow area for pervious embankment materials. Composed chiefly of coarse and medium sand with minor amounts of gravel and some fine sand. Area is wooded.* THIS AREA IS NOT NOW AVAILABLE.	*Permissible borrow area for impervious embankment and random embankment materials, and for top soil dressing. Selected portions of overburden irregularly deposited from 1 foot to about 6 feet in depth, composed chiefly of fine sand and coarse to medium silt are suitable for impervious blanket construction and top soil dressing. Remaining portion of overburden, composed of fine sand and coarse silt, suitable only for construction of random embankment section.*

DATE	REVISION	REV. BY	CK. BY	AP. BY

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

FISCAL YEAR 1939 SECTION

BORROW AREAS

CONNECTICUT & MILL RIVERS — MASSACHUSETTS

IN 21 SHEETS — SCALE: 1 IN. = 1000 FT. — SHEET NO. 4

1000' 0 1000' 2000'

U. S. ENGINEER OFFICE, PROVIDENCE, R.I., APRIL 1939

SUBMITTED: SENIOR GEOLOGIST, HEAD GEOLOGY SECTION

APPROVAL RECOMMENDED: PRINCIPAL ENGINEER, CHIEF, F.C. ENGINEERING DIV.

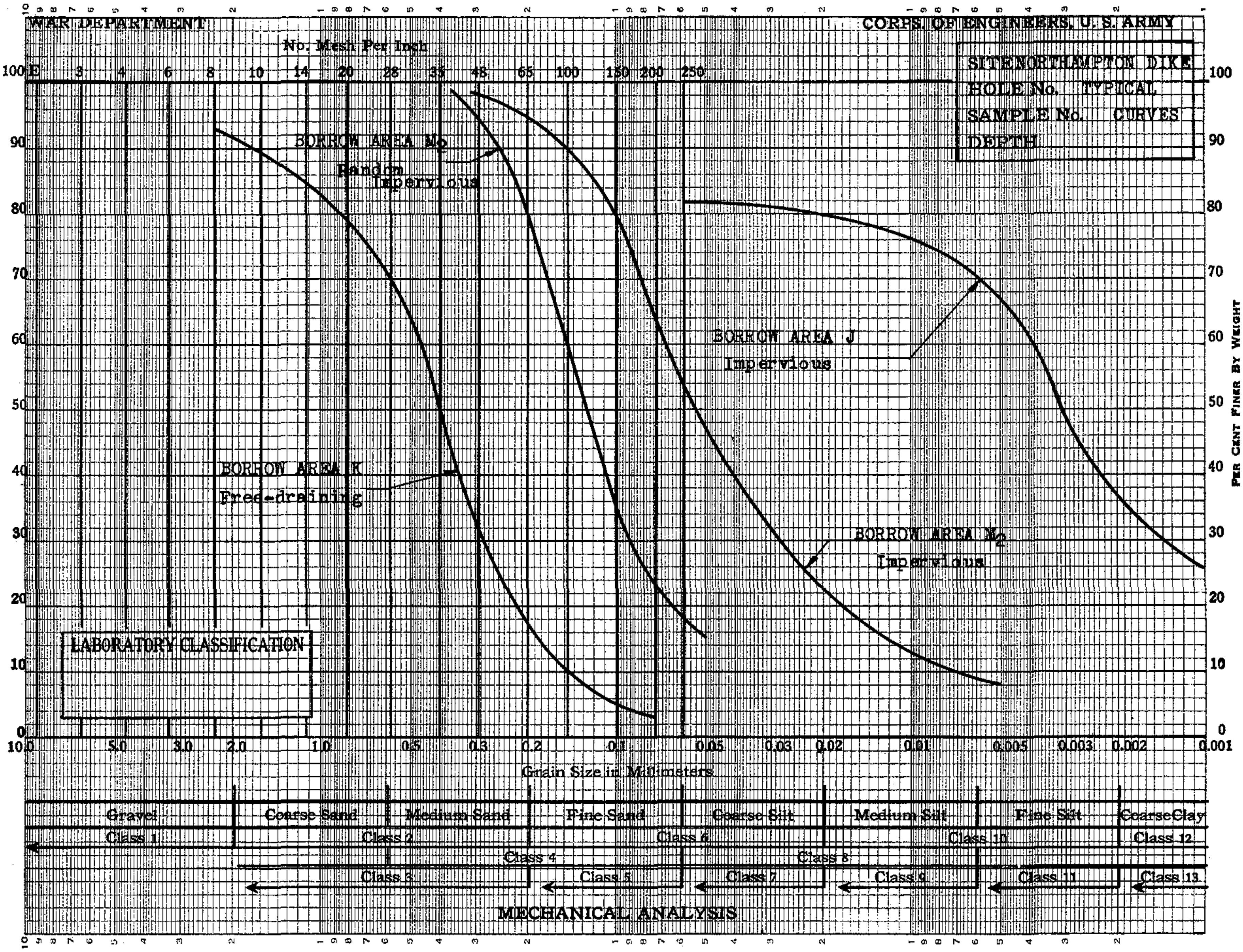
APPROVED: LT. COL., CORPS OF ENGINEERS, DISTRICT ENGINEER

COMPILED: ASST. ENGINEER

DRAWN BY: P.H.S.
TRACED BY: L.A.O.
CHECKED BY: T.H.S.

FILE NO. CT-2-1153

PLATE NO. 5



WAR DEPARTMENT
CORPS OF ENGINEERS, U. S. ARMY
No. Mesh Per Inch
SITE NORTHAMPTON DIKE
HOLE No. TYPICAL
SAMPLE No. CURVES
DEPTH
BORROW AREA M_0
Random
Impervious
BORROW AREA J
Impervious
BORROW AREA K
Free-draining
BORROW AREA M_2
Impervious
LABORATORY CLASSIFICATION
PER CENT FINER BY WEIGHT
Grain Size in Millimeters
Gravel
Coarse Sand
Medium Sand
Fine Sand
Coarse Silt
Medium Silt
Fine Silt
Coarse Clay
Class 1
Class 2
Class 3
Class 4
Class 5
Class 6
Class 7
Class 8
Class 9
Class 10
Class 11
Class 12
Class 13
MECHANICAL ANALYSIS

PLATE NO. 6

PLATE NO. 7

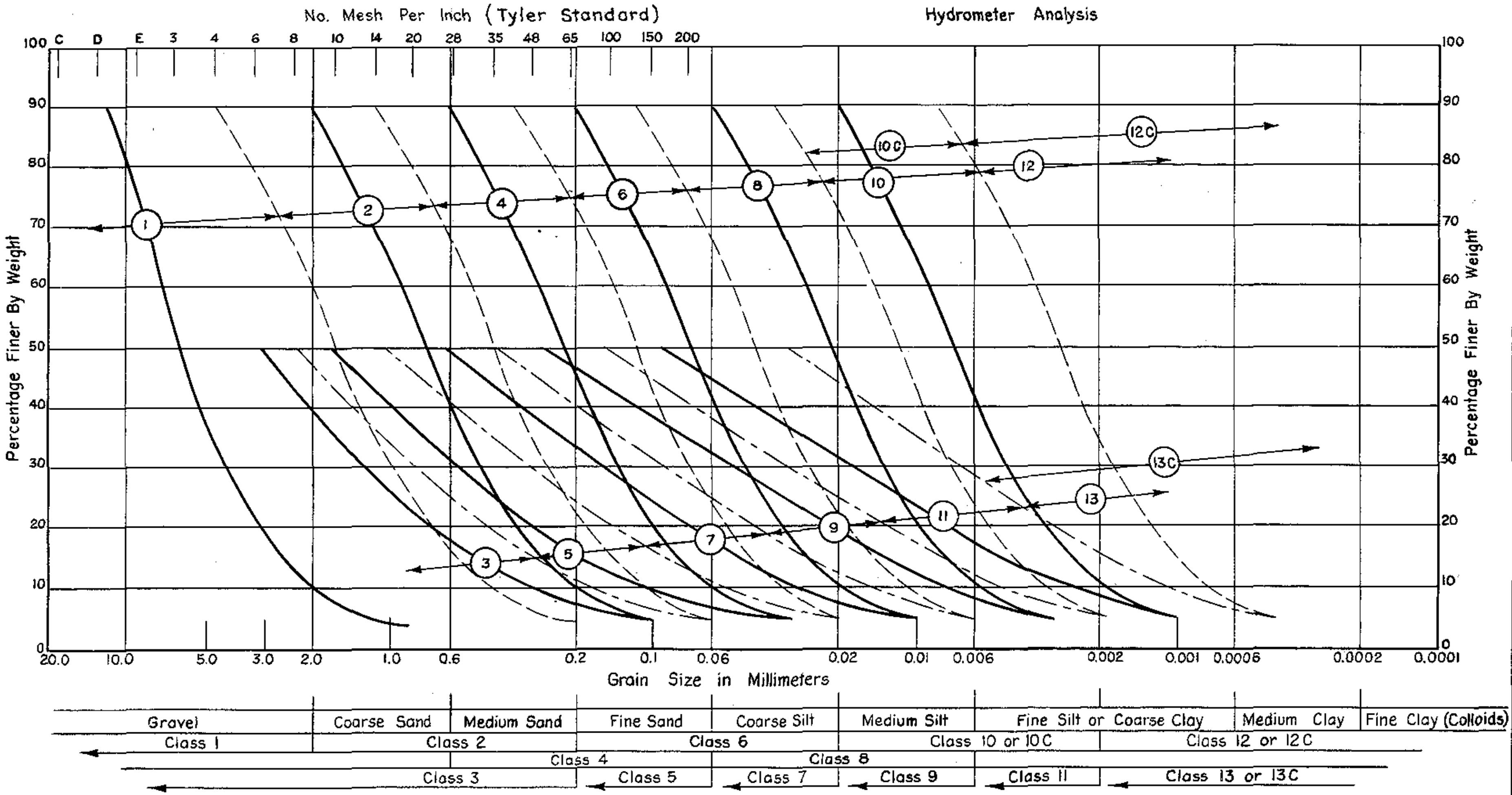


DIAGRAM SHOWING LIMITS OF SOIL CLASSES

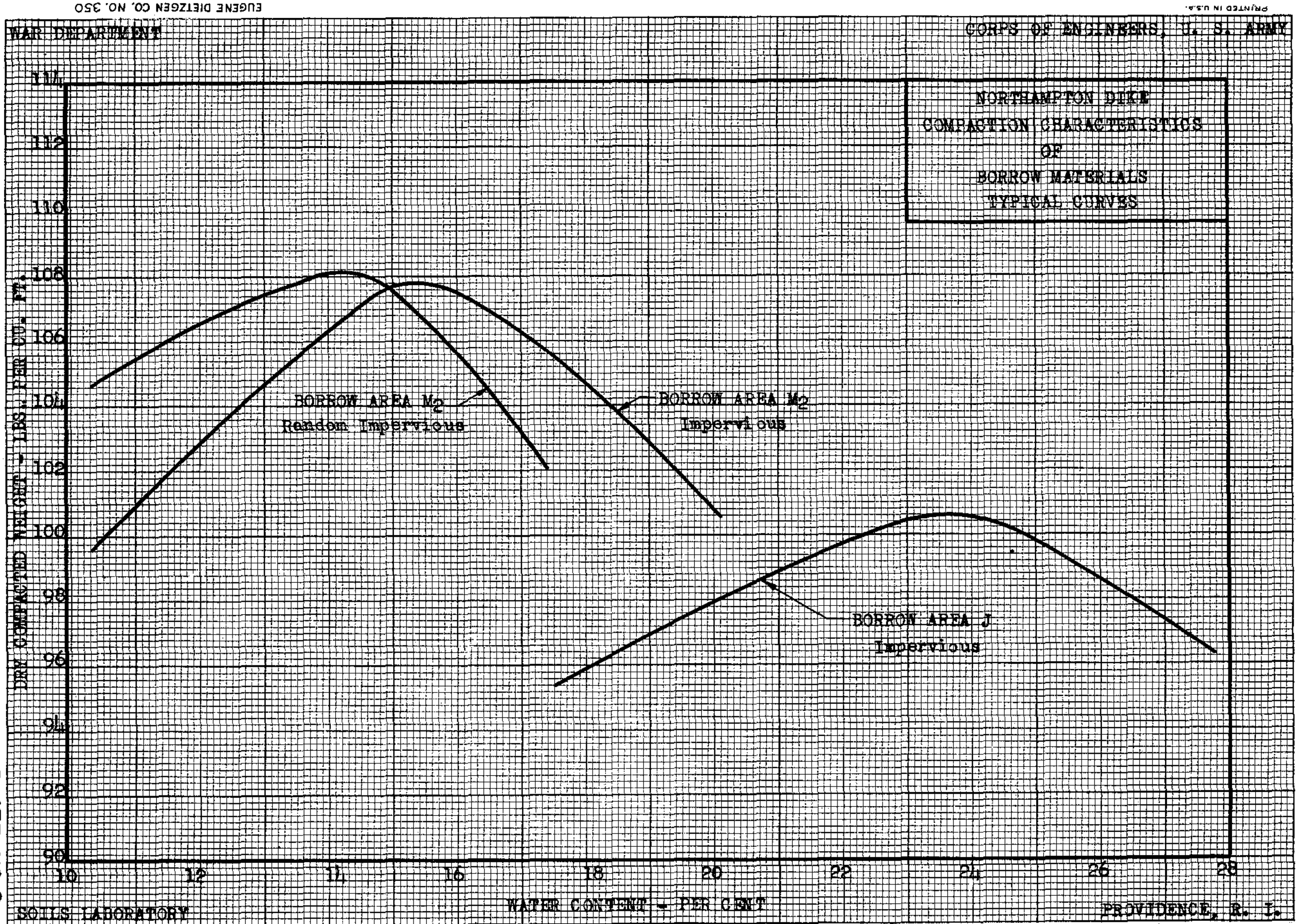

EUGENE DIETZGEN CO. NO. 350
PRINTED IN U.S.A.
WAR DEPARTMENT
CORPS OF ENGINEERS, U. S. ARMY
NORTHAMPTON DIKE
COMPACTION CHARACTERISTICS
OF
BORROW MATERIALS
TYPICAL CURVES
DRY COMPACTED WEIGHT - LBS. PER CU. FT.
114
112
110
108
106
104
102
100
98
96
94
92
90
BORROW AREA M2
Random Impervious
BORROW AREA M2
Impervious
BORROW AREA J
Impervious
10
12
14
16
18
20
22
24
26
28
WATER CONTENT - PER CENT
SOILS LABORATORY
PROVIDENCE, R. I.

PLATE NO. 8

WAR DEPARTMENT CORPS OF ENGINEERS, U. S. ARMY

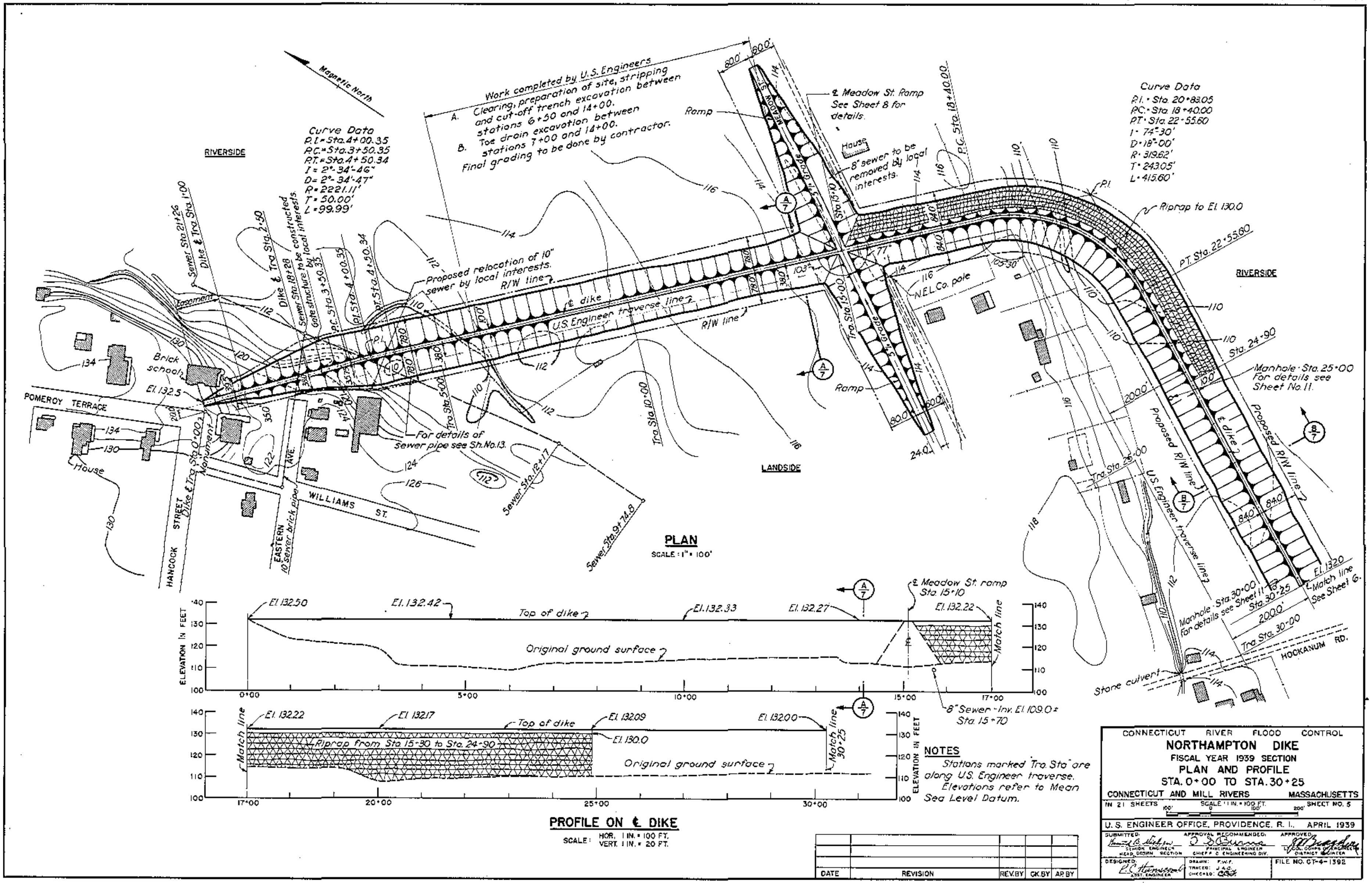


PLATE NO. 9

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY

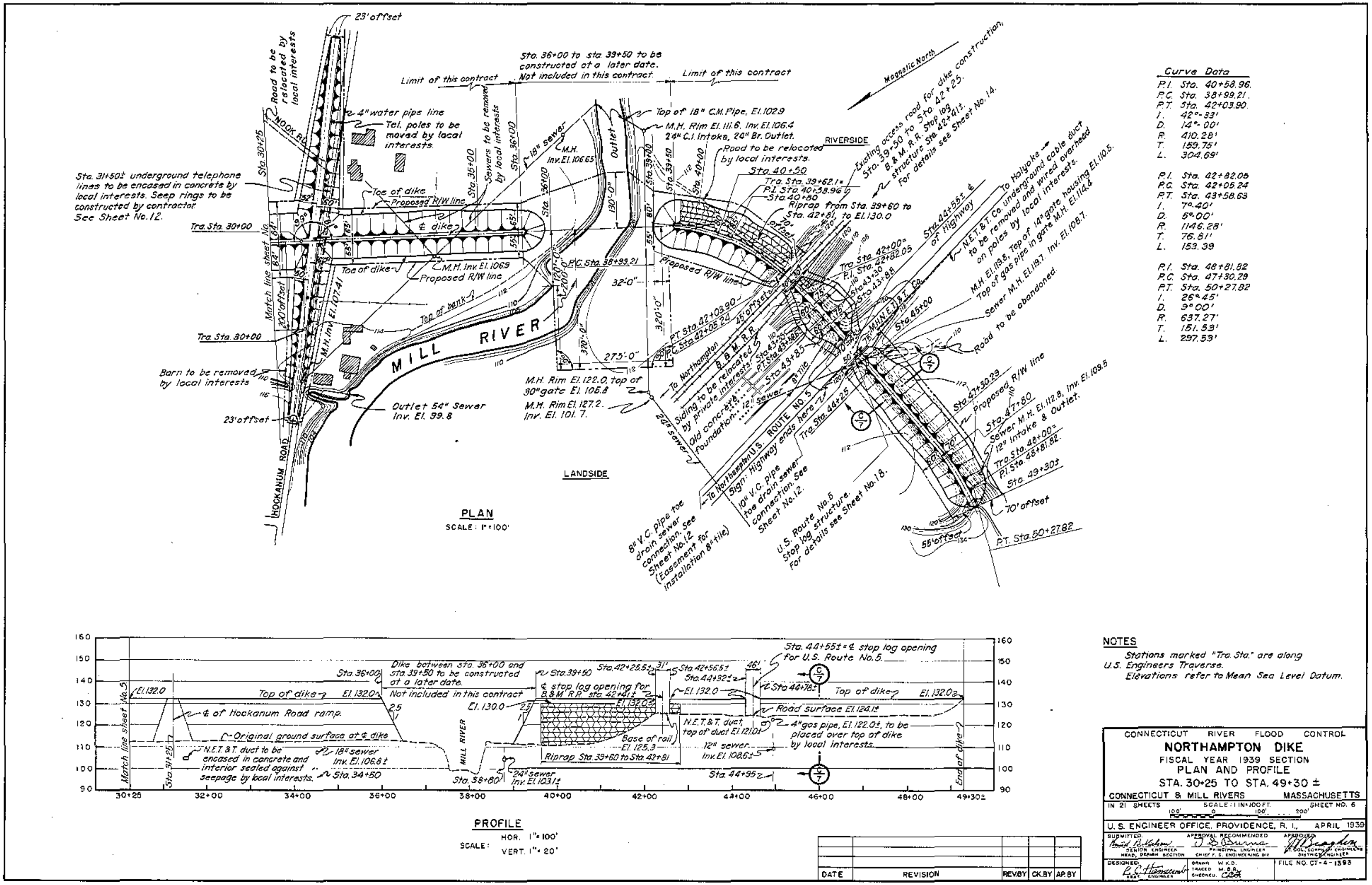


PLATE NO. 10

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY

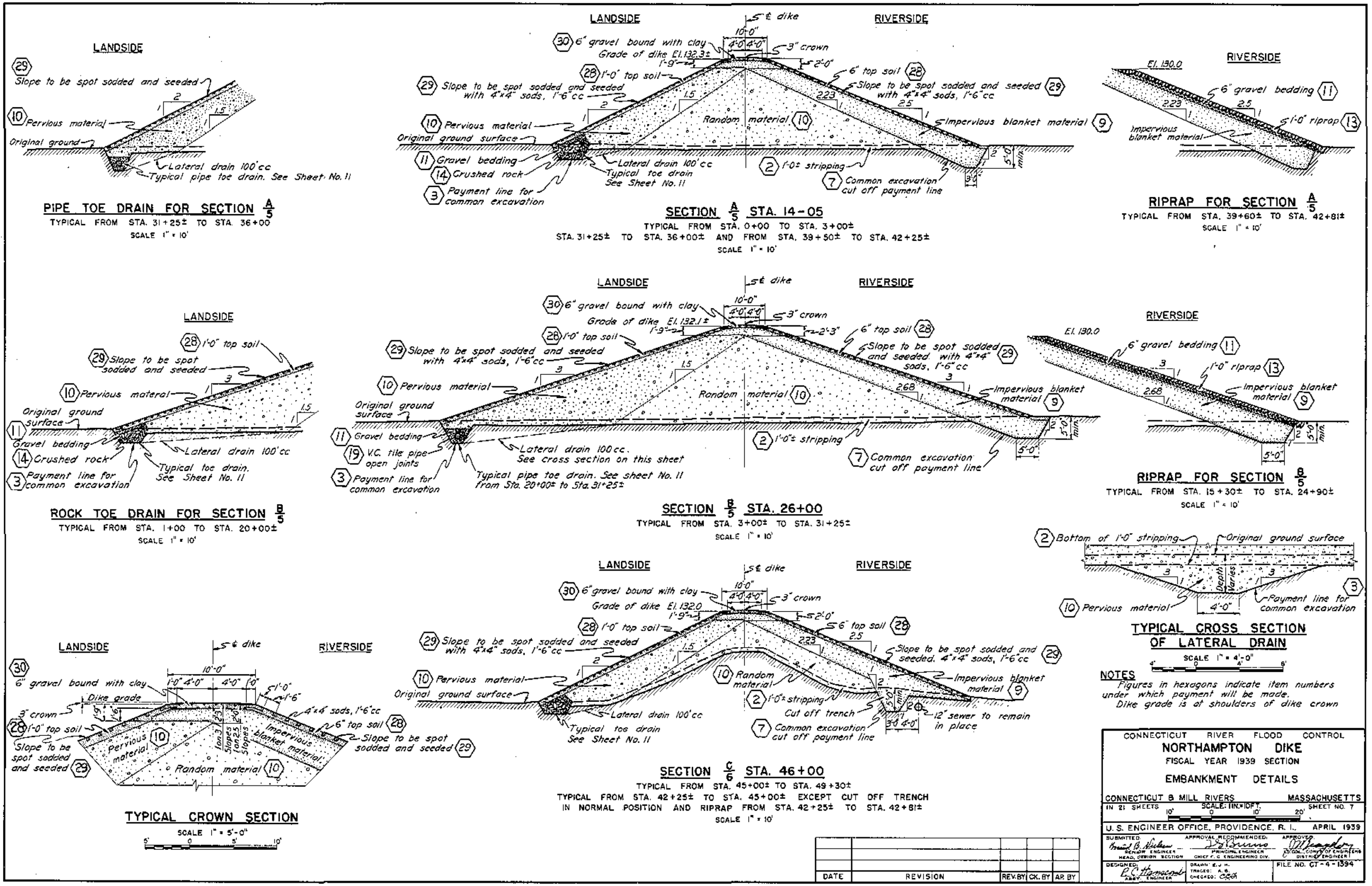
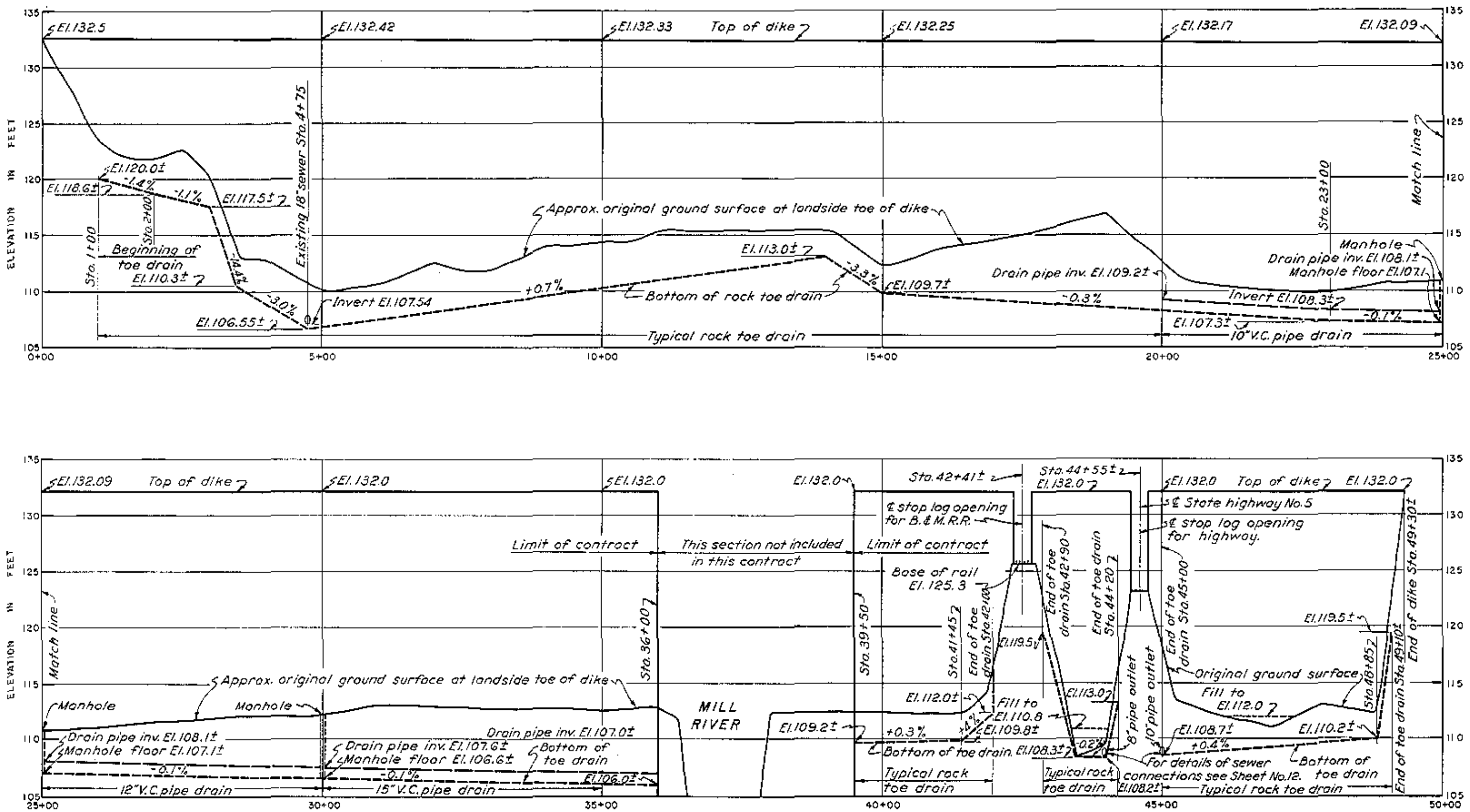


PLATE NO. 11

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY



TOE DRAIN PROFILE

SCALE: HOR. 1" = 100'
VERT. 1" = 5'

NOTE

Elevations refer to Mean Sea Level Datum.

DATE	REVISION	REV. BY	CK. BY	AP. BY

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

FISCAL YEAR 1939 SECTION

TOE DRAIN PROFILE

CONNECTICUT & MILL RIVERS — MASSACHUSETTS

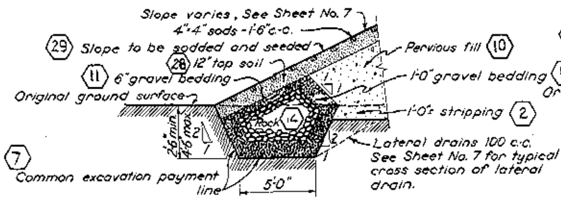
IN 21 SHEETS — SCALE AS SHOWN — SHEET NO. 10

U. S. ENGINEER OFFICE, PROVIDENCE, R. I., APRIL 1939

SUBMITTED: SENIOR ENGINEER, HEAD, DESIGN SECTION — APPROVAL RECOMMENDED: PRINCIPAL ENGINEER, CHIEF F. C. ENGINEERING DIV. — APPROVED: LT. COL., CORPS OF ENGINEERS, DISTRICT ENGINEER

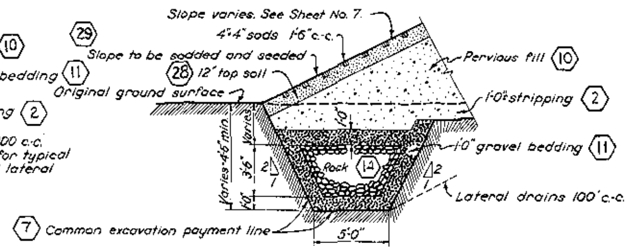
DESIGNED: ASST. ENGINEER — DRAWN: H.S.H. TRACED: A.T. CHECKED: — FILE NO. CT-4-1597

PLATE NO. 12



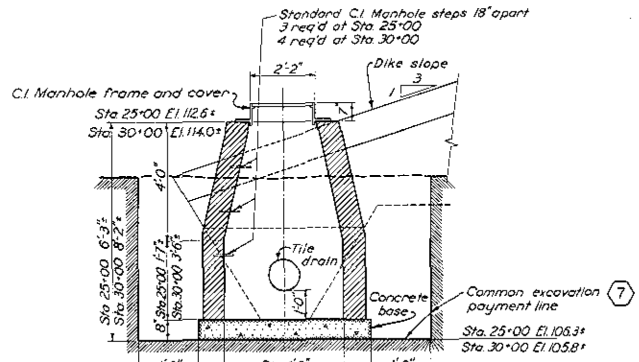
2'-6" TO 4'-6" DEPTHS

TYPICAL FROM STA. 0+00 TO STA. 16+00±, STA. 39+50± TO STA. 42+00±, STA. 45+30± TO STA. 46+25± AND FROM STA. 47+25± TO STA. 49+10±



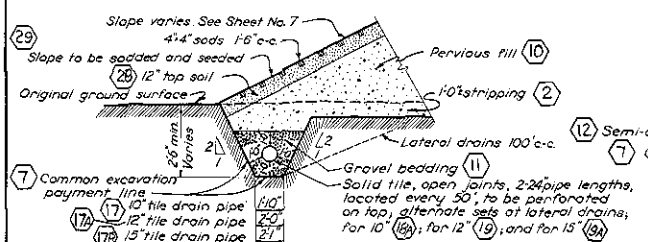
4'-6" AND GREATER DEPTHS

TYPICAL FROM STA. 16+10± TO STA. 20+00± AND FROM STA. 44+85± TO STA. 45+30±



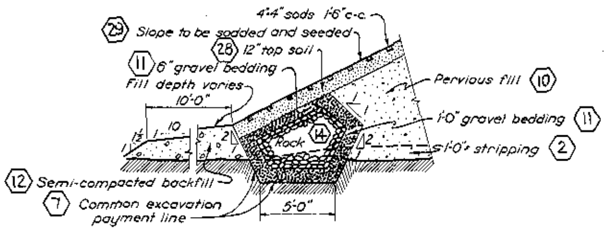
DETAIL OF BRICK MANHOLES 33

SCALE: $\frac{1}{2}$" = 1'-0"



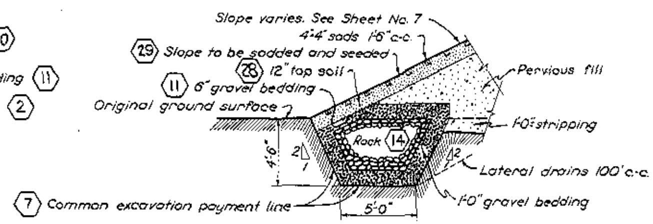
PIPE TOE DRAIN

TYPICAL FROM STA. 20+00± TO STA. 36+00±



2'-6" TO 4'-6" DEPTHS WITH FILL

TYPICAL FROM STA. 42+50± TO STA. 44+20± AND FROM STA. 46+25± TO STA. 47+25±



4'-6" DEPTH

THIS SECTION IS USED AT 4'-6" DEPTH WHEN DEPTH IS INCREASING

TYPICAL TOE DRAIN CROSS SECTIONS

SCALE: $\frac{1}{4}$" = 1'-0"

NOTE

Figures in hexagons indicate item numbers under which payment will be made.

DATE	REVISION	REV. BY	CK. BY	AP. BY

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

FISCAL YEAR 1939 SECTION

TOE DRAIN SECTIONS AND DETAILS

CONNECTICUT & MILL RIVERS — MASSACHUSETTS

IN 21 SHEETS — SCALE: 1/4 IN. = 1 FT. — SHEET NO. 11

U. S. ENGINEER OFFICE, PROVIDENCE, R. I. — APRIL 1939

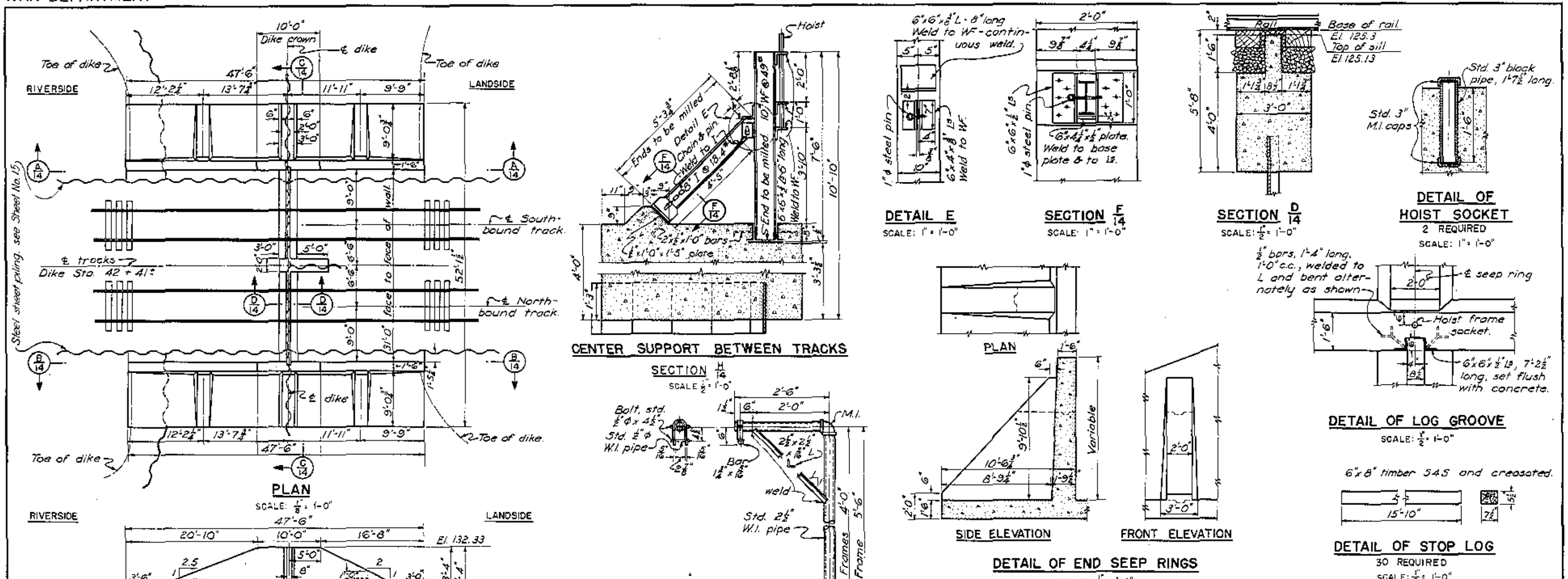
SUBMITTED: SENIOR ENGINEER, HEAD, DESIGN SECTION — APPROVAL RECOMMENDED: PRINCIPAL ENGINEER, CHIEF F. C. ENGINEERING DIV. — APPROVED: LT. COL., CORPS OF ENGINEERS, DISTRICT ENGINEER

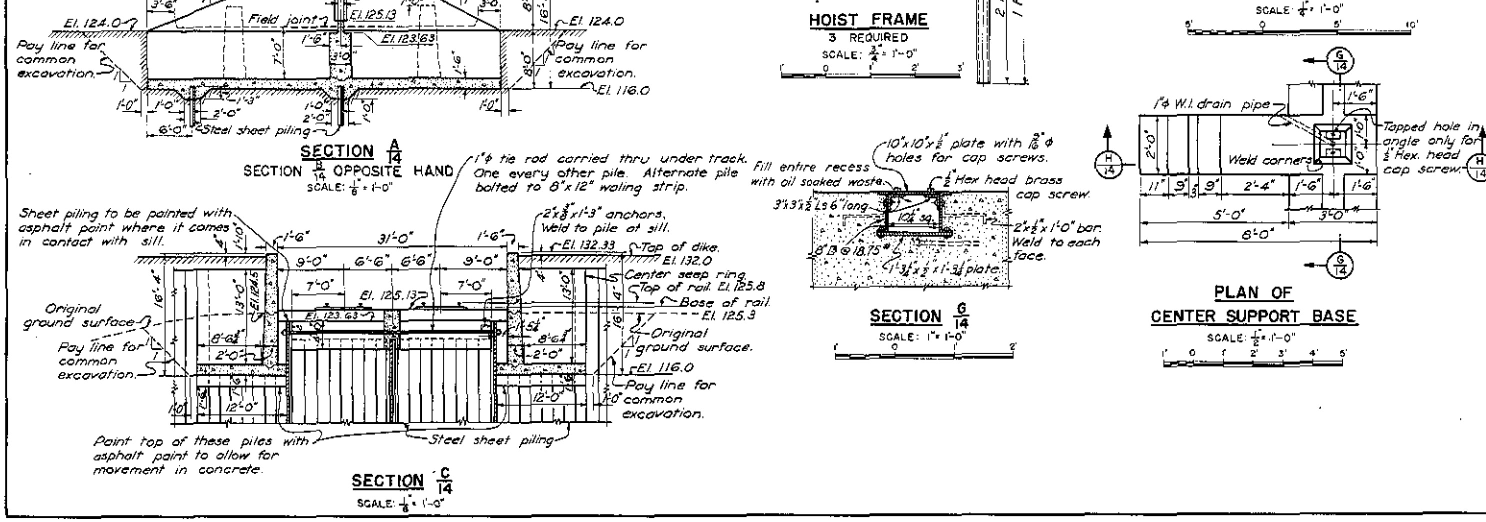
DESIGNED: ASST. ENGINEER — DRAWN: W.H.D. TRACED: J.A.C. CHECKED — FILE NO. CT-4-1398

PLATE NO. 13

WAR DEPARTMENT

CORPS OF ENGINEERS. U. S. ARMY





NOTES

All rivets 3/4" φ.

Open holes 7/8" φ, except as noted.

Furnishing, fabricating, welding, erecting and painting all miscellaneous structural steel indicated on this sheet will be paid for at contract price under Item No. 25.

Furnishing and installing all miscellaneous metals indicated on this sheet will be paid for at contract price under Item No. 26.

All concrete shown on this sheet shall be Class "A" and will be paid for at contract price under Item No. 22.

All timber shown on this sheet shall be White Oak (structural grade and creosoted) and will be paid for at contract price under Item No. 27.

For steel reinforcement details see Sheets No. 16 & 17

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

FISCAL YEAR 1939 SECTION

B. & M. R.R. STOP-LOG STRUCTURE

CONCRETE DETAILS

CONNECTICUT & MILL RIVERS, MASSACHUSETTS

IN 21 SHEETS — SCALE: 1/8 IN. = 1 FT. — SHEET NO. 14

U. S. ENGINEER OFFICE, PROVIDENCE, R. I. — APRIL 1939

SUBMITTED: SENIOR ENGINEER, HEAD, DESIGN SECTION — APPROVAL RECOMMENDED: PRINCIPAL ENGINEER, CHIEF F. C. ENGINEERING DIV. — APPROVED: COL., CORPS OF ENGINEERS, DISTRICT ENGINEER

DESIGNED: ASSOC. ENGINEER — DRAWN: H.E.W. TRACED: O.B.C. CHECKED: — FILE NO. CT-4-1401

PLATE NO. 14

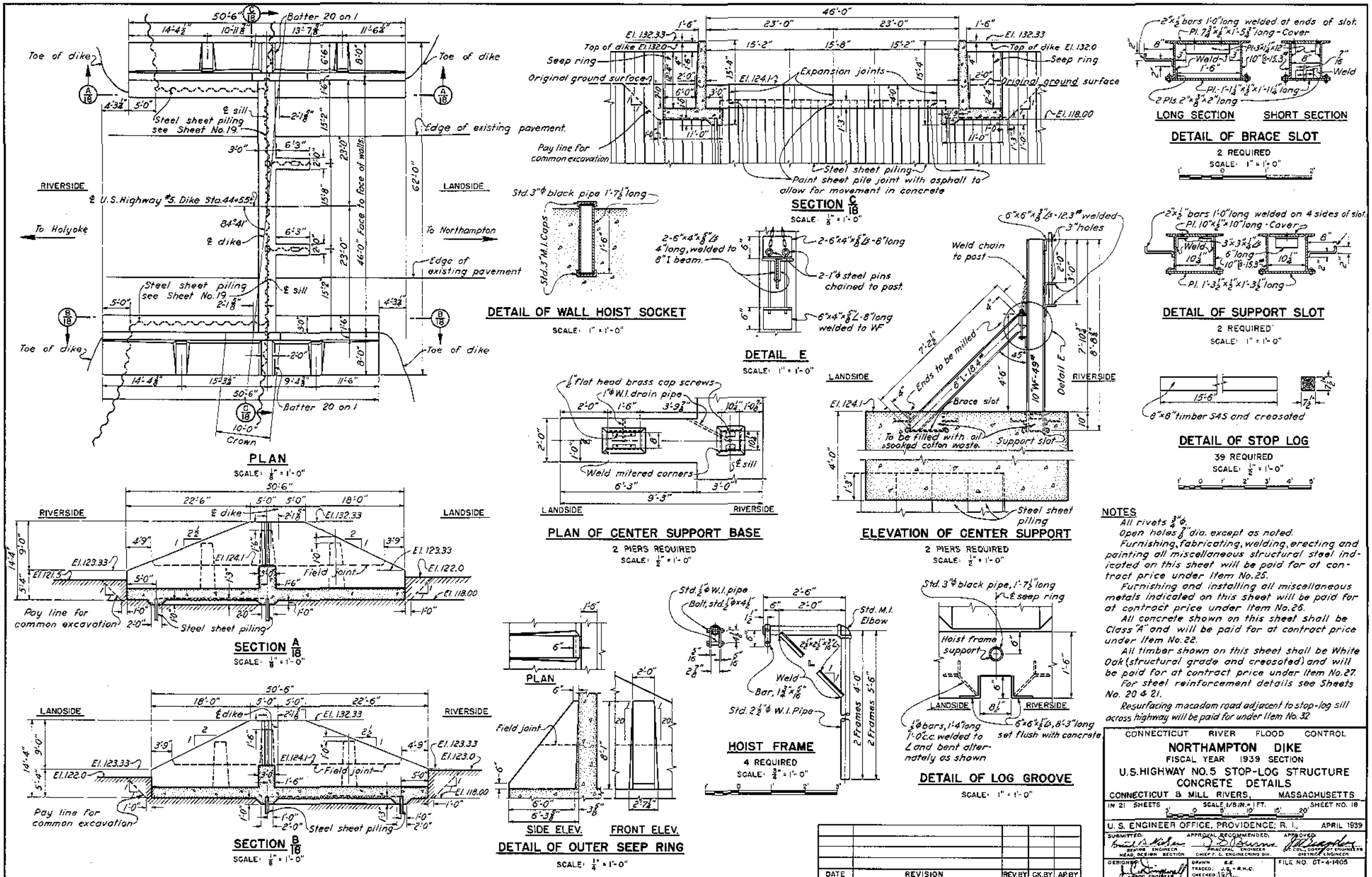
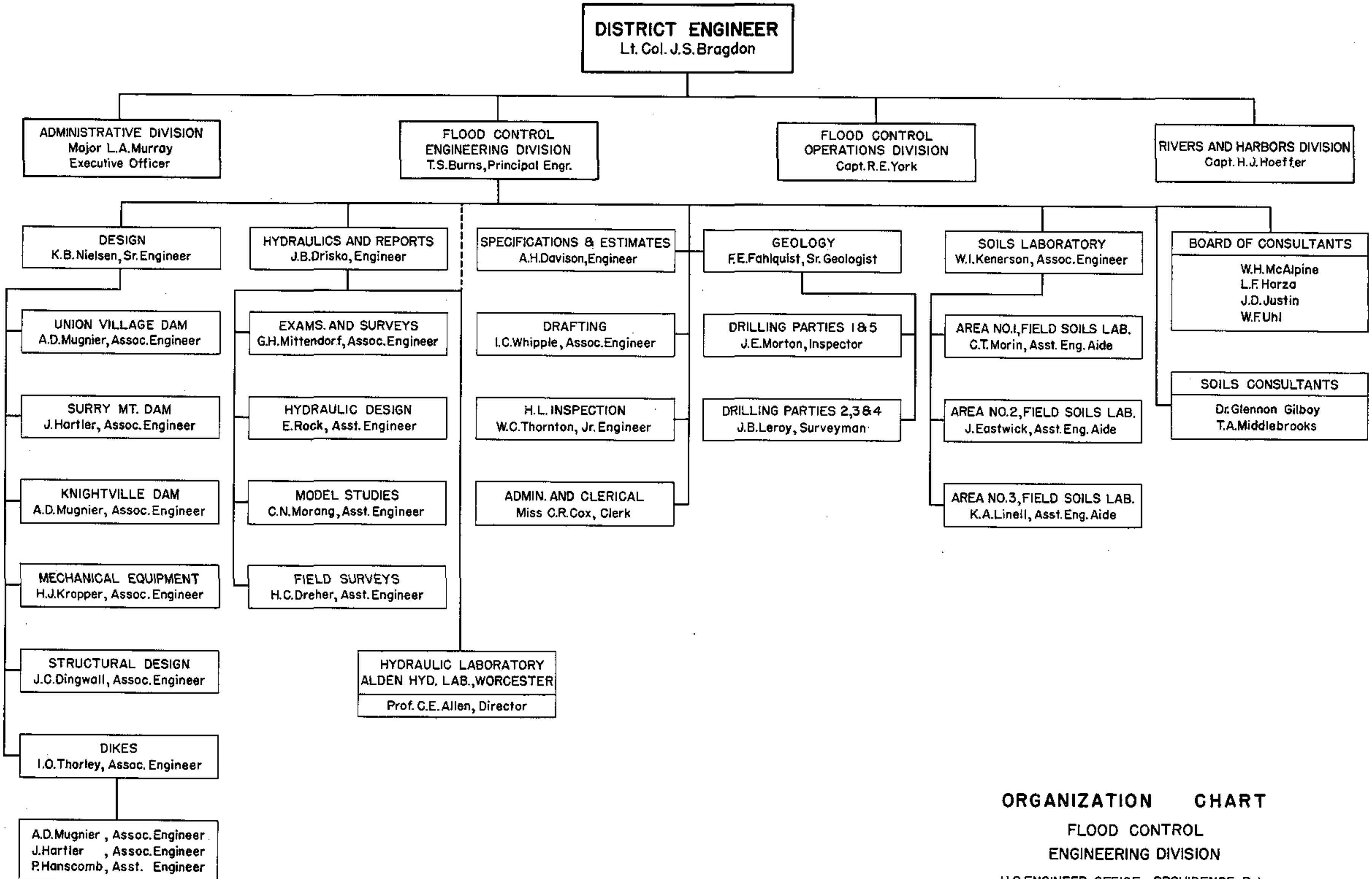

PLAN
SCALE: 1/8" = 1'-0"
SECTION A/18
SCALE: 1/8" = 1'-0"
SECTION B/18
SCALE: 1/8" = 1'-0"
SECTION C/18
SCALE: 1/8" = 1'-0"
DETAIL OF WALL HOIST SOCKET
SCALE: 1" = 1'-0"
DETAIL E
SCALE: 1" = 1'-0"
PLAN OF CENTER SUPPORT BASE
2 PIERS REQUIRED
SCALE: 1/2" = 1'-0"
ELEVATION OF CENTER SUPPORT
2 PIERS REQUIRED
SCALE: 1/2" = 1'-0"
DETAIL OF OUTER SEEP RING
SCALE: 1/4" = 1'-0"
HOIST FRAME
4 REQUIRED
SCALE: 3/4" = 1'-0"
DETAIL OF LOG GROOVE
SCALE: 1" = 1'-0"
DETAIL OF BRACE SLOT
2 REQUIRED
SCALE: 1" = 1'-0"
DETAIL OF SUPPORT SLOT
2 REQUIRED
SCALE: 1" = 1'-0"
DETAIL OF STOP LOG
39 REQUIRED
SCALE: 1/2" = 1'-0"
8"×8" timber S4S and creosoted
RIVERSIDE
LANDSIDE
To Holyoke
To Northampton
℄ U.S. Highway #5. Dike Sta. 44+55±
Steel sheet piling see Sheet No. 19.
Edge of existing pavement
Toe of dike
Batter 20 on 1
Pay line for common excavation
NOTES
All rivets 3/4"φ.
Open holes 7/8" dia. except as noted.
Furnishing, fabricating, welding, erecting and painting all miscellaneous structural steel indicated on this sheet will be paid for at contract price under Item No. 25.
Furnishing and installing all miscellaneous metals indicated on this sheet will be paid for at contract price under Item No. 26.
All concrete shown on this sheet shall be Class "A" and will be paid for at contract price under Item No. 22.
All timber shown on this sheet shall be White Oak (structural grade and creosoted) and will be paid for at contract price under Item No. 27.
For steel reinforcement details see Sheets No. 20 & 21.
Resurfacing macadam road adjacent to stop-log sill across highway will be paid for under Item No. 32
CONNECTICUT RIVER FLOOD CONTROL
NORTHAMPTON DIKE
FISCAL YEAR 1939 SECTION
U.S. HIGHWAY NO. 5 STOP-LOG STRUCTURE
CONCRETE DETAILS
CONNECTICUT & MILL RIVERS, MASSACHUSETTS
IN 21 SHEETS
SCALE 1/8 IN. = 1 FT.
SHEET NO. 18
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.,
APRIL 1939
FILE NO. CT-4-1405
DATE
REVISION
REV. BY
CK. BY
AP. BY

PLATE NO. 15



ORGANIZATION CHART

FLOOD CONTROL
ENGINEERING DIVISION

U.S. ENGINEER OFFICE, PROVIDENCE, R. I.

PLATE NO. 16

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

CONNECTICUT & MILL RIVERS MASSACHUSETTS

FISCAL YEAR 1939 SECTION — CONTRACT
STA. 0 TO HIGH GROUND OVER RAILROAD AND HIGHWAY

N.2

ANALYSIS OF DESIGN

1939

APPENDIX A

CORPS OF ENGINEERS, U.S. ARMY

U.S. ENGINEER OFFICE PROVIDENCE, R.I.

APPENDIX "A"

SECTION "A"

STRUCTURAL COMPUTATIONS FOR BOSTON AND MAINE RAILROAD STOP-LOG STRUCTURE AT NORTHAMPTON, MASS.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page A-1

Subject Stop Log Structure – B & M R.R. – Northampton Dike

Computation Alternate Design #1 – 2 main tracks only

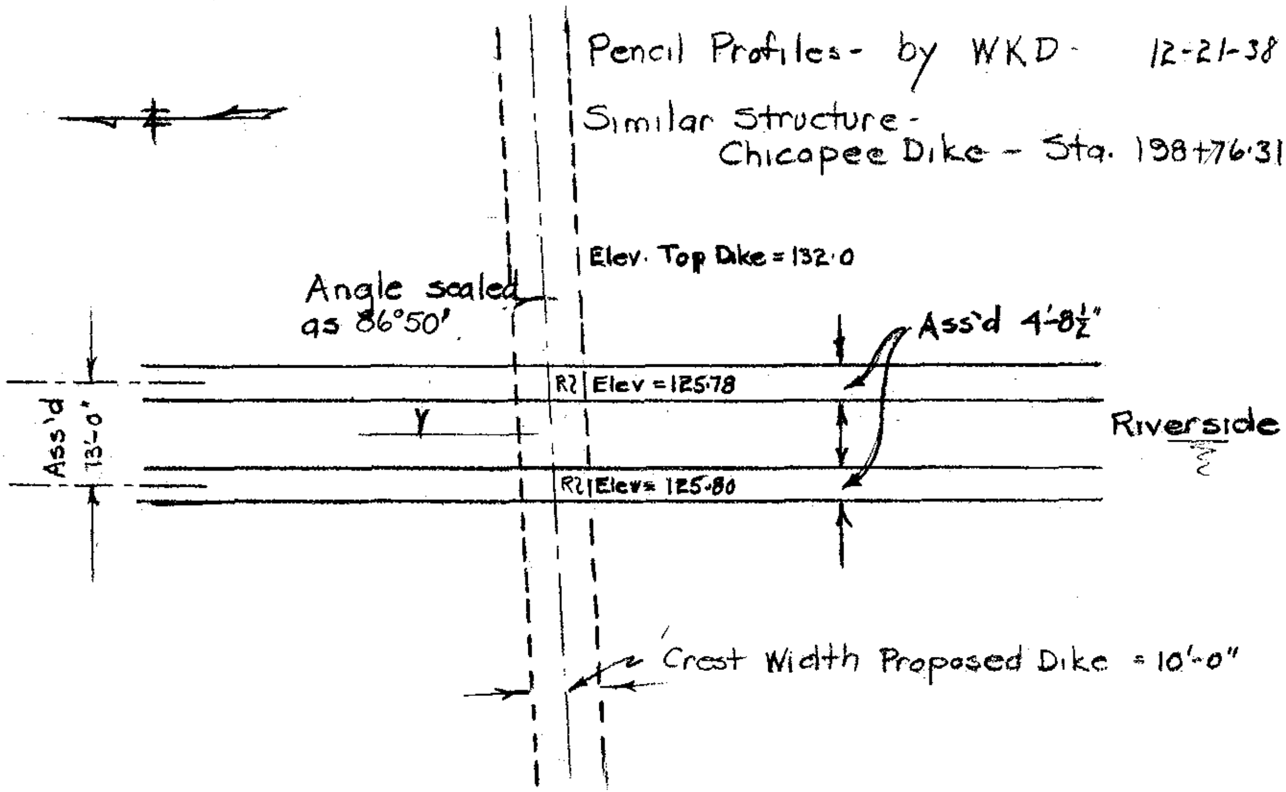
Computed by C.W.B. McC. **Checked by** .... **Date** 12-23-38

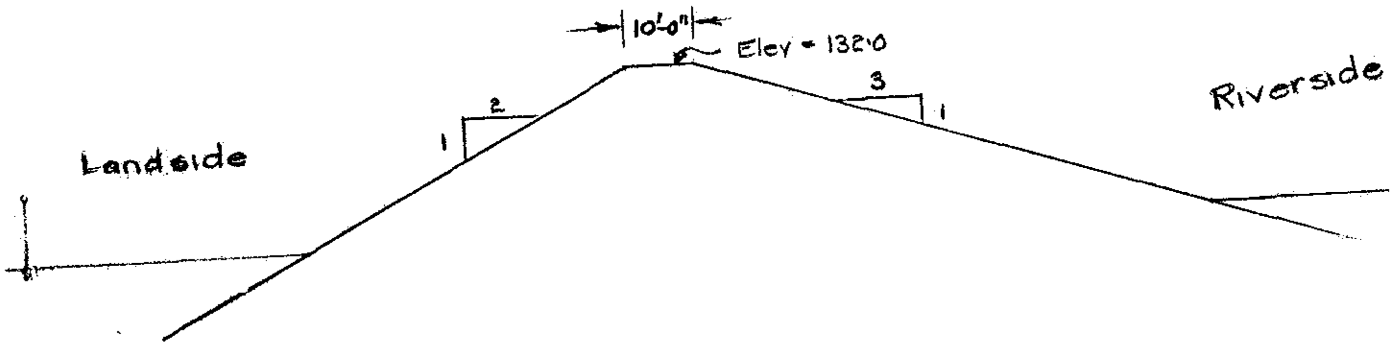
U.S. GOVERNMENT PRINTING OFFICE 3—10528

For references – see File No CT-5-1175 – Sheet #1

Pencil Profiles – by WKD – 12-21-38

Similar Structure – Chicopee Dike – Sta. 198+76.31





WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page A-2

Subject Stop Log Structure – B & M RR - Northampton Dike

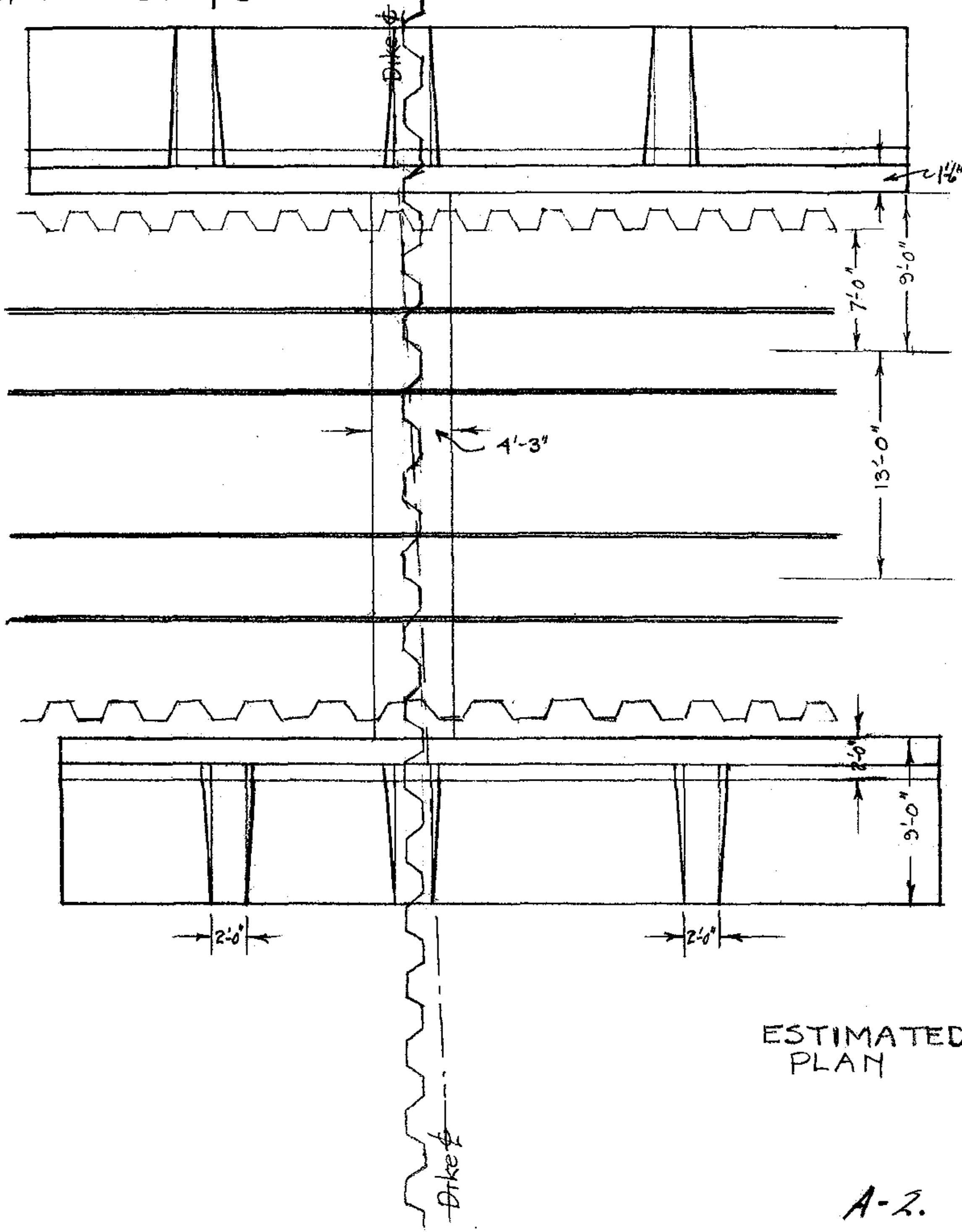
Computation Alt. Dsgn #1

Computed by CWBM Checked by ________ Date 12-23-38

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Scale 1"=8'

For initial dimensions, as many features as possible are taken from Chicopee



ESTIMATED PLAN

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page A-3

Subject Stop Log Structure - B & M R.R. - Northampton Dike

Computation Alt. Dsgn #1

Computed by CWBM   Checked by   Date 12-23-38

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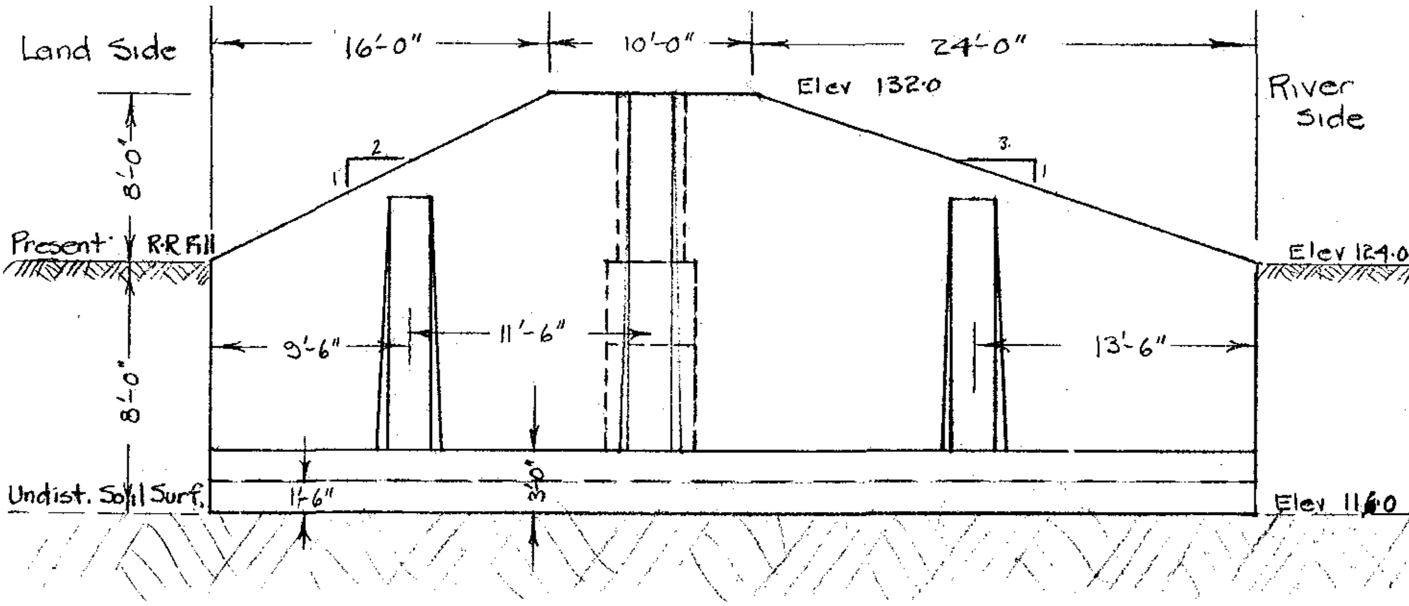
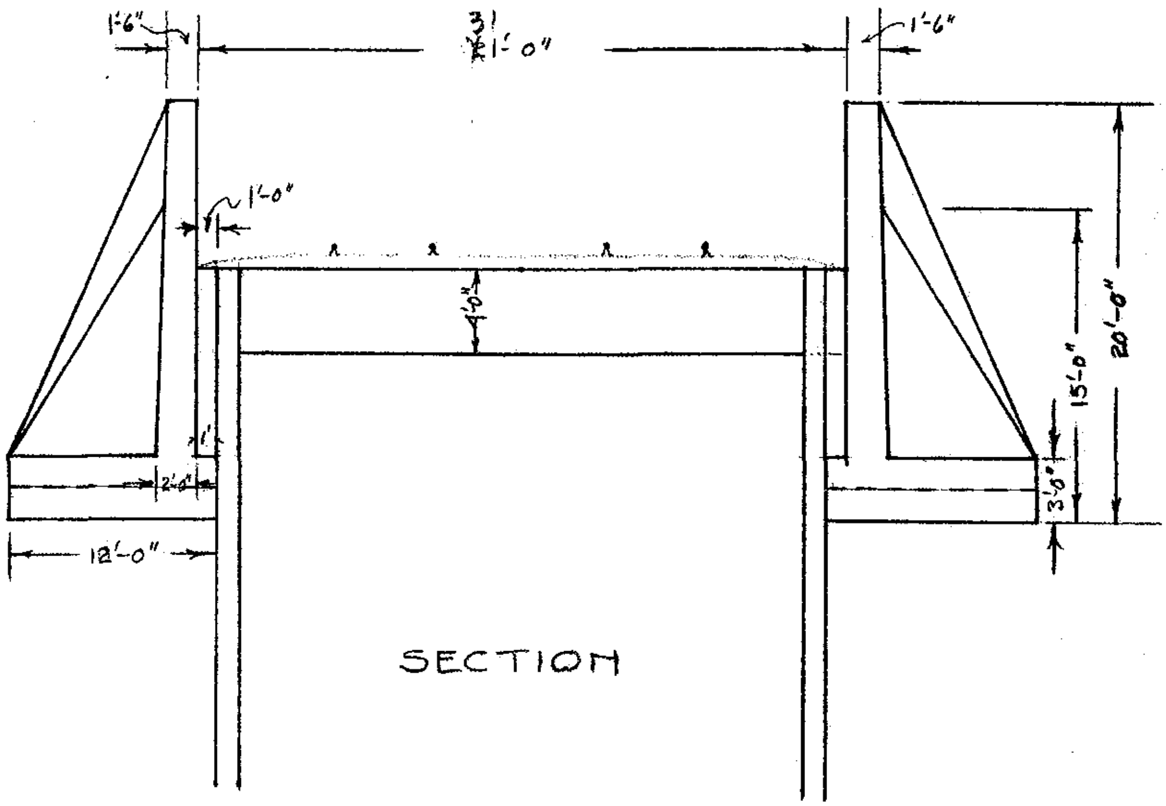


ELEVATION



SECTION

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page A-4

Subject NORTHAMPTON - B & M R.R.

Computation Stop-Log Structure - Base Width 12.0'

Computed by S.H.B. Checked by G.P.J. Date 1-21-39

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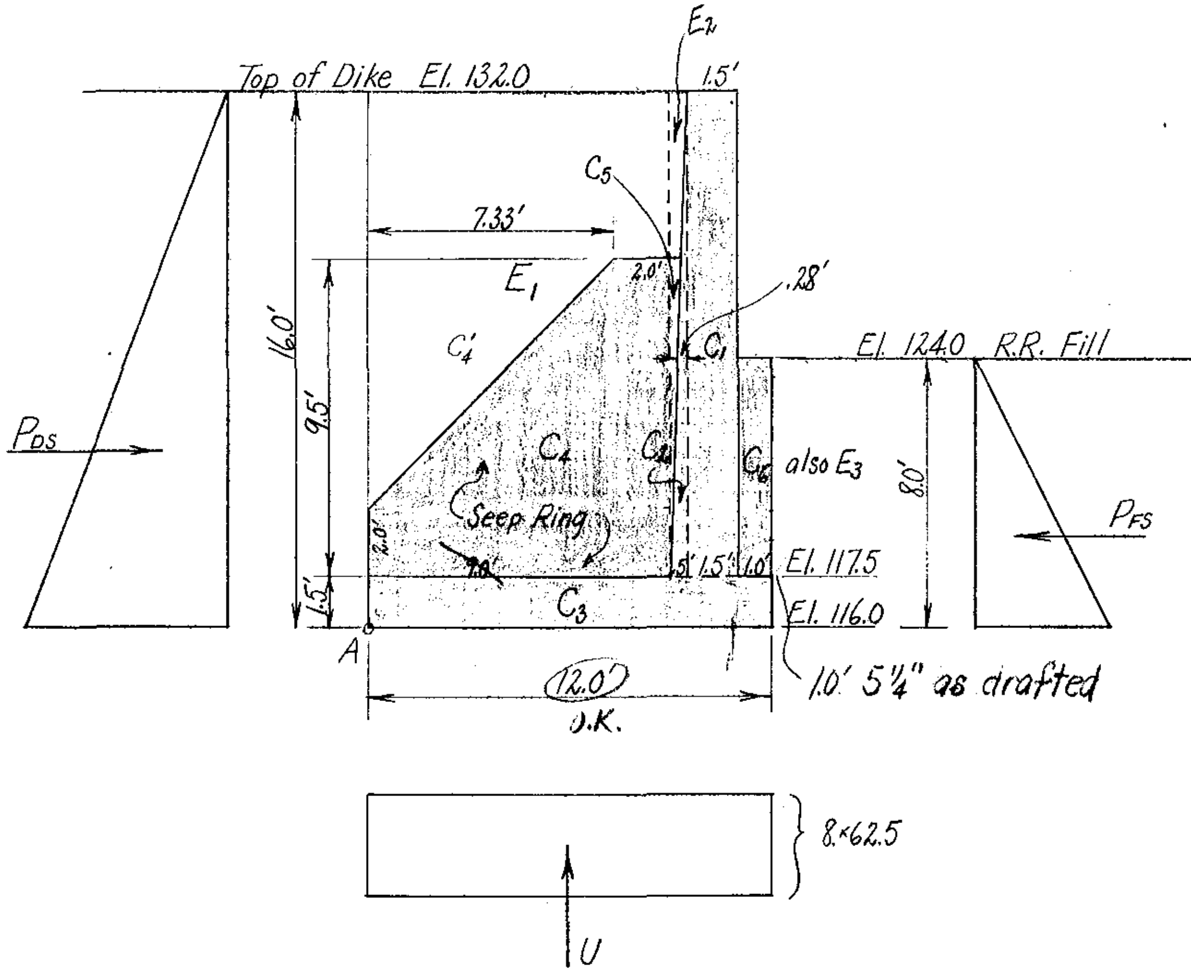

Three Seep Rings in 50' of Wall with assumed thickness of 2.0' and equal heights, although seep ring at center of dike should be to top of dike.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page A-5

Subject Stop Log Structure - B & M RR - Northampton Dike

Computation Trapezoidal Earth Loadings

Computed by CWBM Checked by Date 1-18-39

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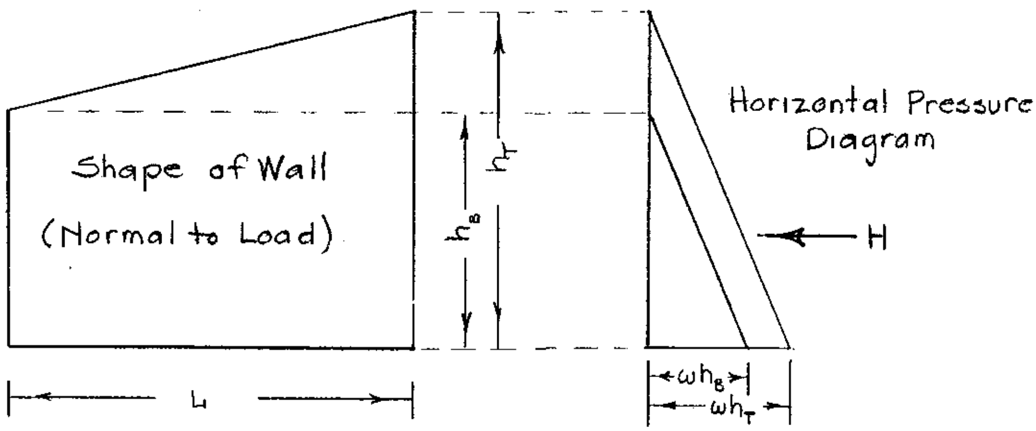
Method of computing Trapezoidal Earth Loads -



Let ω be the equivalent liquid weight of the earth

Let n be the ratio of end heights $= \frac{h_T}{h_B}$

Total horizontal thrust

$$H = \frac{\omega h_B^2 L}{6} (1 + n + n^2)$$

Total moment about base

$$M = \frac{\omega h_B^3 L}{24} (1 + n + n^2 + n^3)$$

Dividing -- effective lever arm $= \frac{M}{H}$

$$e = \frac{h_B}{4} \frac{(1+n+n^2+n^3)}{(1+n+n^2)}$$

Subject NORTHAMPTON - B & M R.R.
Computation Stop-Log Structure - Base Width 12.0'
Computed by S.H.B. **Checked by**
Date 1-21-39

		Dimensions Width × ht × lgth	Unit Wt.	↓	↑	→	←	Arm	↷ Moments	↶
Wall	C_1	1.5 × 14.5 × 50.0	150	163,200.				10.25	1,674,000.	
	C_2	.5 × 14.5 × 50.0 × ½	150	27,200.				9.33	272,000.	
	C'	1.5 × 8.0 × 24.0 × ½	150		21,600.			10.25	254 000	221,000.
	"	1.5 × 8.0 × 16.0 × ½	150		14,400.			10.25		147,500.
	"	.28 × 8.0 × 24.0 × ⅓	150		2,690.			9.43		25,400.
	"	.28 × 8.0 × 16.0 × ⅓	150		1,790.			9.43		16,900.
Slab	C_3	12.0 × 1.5 × 50.0	150	135,000.				6.0	810,000.	
Seep Rings	C_4	9.0 × 9.5 × 2.0 × 3	25	12,820.				4.5	57,700.	
	C_4'	7.33 × 7.5 × 2.0 × 3/2	25		4,130.			2.44		10,100.
	C_5	.33 × 7.5 × 2.0 × 3/2	25	186.				9.11	1700 1,860	
	C_6	1.0 × 6.5 × 4.5	25	731.				11.5	8,420.	
	E_1	9.0 × 11.3 × 50.0	125	636,000.				4.5	2,860,000.	
	E_2	.5 × 11.3 × 50.0 × ½	125	17,670.				9.17	162,000.	
	E_3	1.0 × 6.5 × 50.0	125	40,600.				11.5	467,000.	
	U	12.0 × 8.0 × 50.0	62.5		300,000.			6.0		1,800,000.
	P_{FS}	½ × $\overline{8.0}^2$ × 50.0	80.				128,000.	2.67		342,000.
	P_{DS}	74⅔ × 16.0	80.			95,600.		4.28	409,000.	
		½ × $\overline{16.0}^2$ × 10.0	80.			102,400.		5.33	546,000.	
		74⅔ × 24.0	80.			143,300.		4.28	615,000.	
				Σ 1,033,407.	Σ 344,610.	Σ 341,300	Σ 128,000.		Σ 7,882,980 7,865,820	Σ 2,562,900.

$$\text{Resultant} = \frac{\overset{5302920}{5,320,080.}}{688,800.} = \overset{7.70}{7.73'} \text{ from A} \qquad -e = 12.0/2 - 7.73 = \overset{1.70}{-1.73}$$

$$\text{2/3 point} = 8.00' \quad \therefore \text{O.K.} \qquad e = 1.73'$$

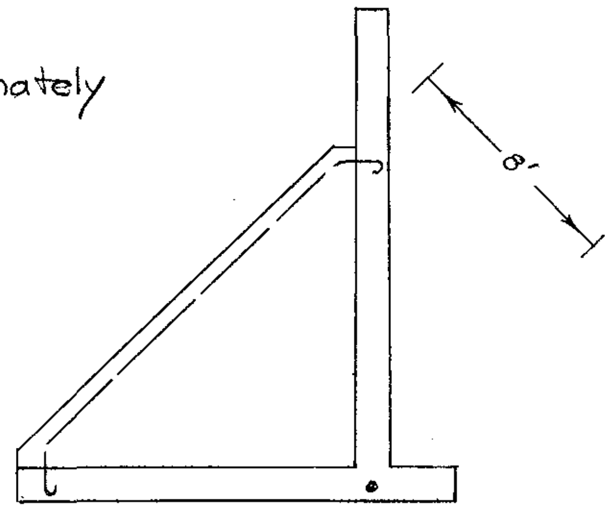
$$\text{Bearing Pressure} = \frac{\Sigma V}{bd}\left(1 \pm \frac{6e}{b}\right) = \left.\begin{array}{l} \overset{2120}{2,140.} \text{ \#/□' at B} \\ 155. \text{ \#/□' at A} \end{array}\right\}$$

172

$$\text{Sliding Factor} = \frac{\Sigma H}{\Sigma V} = .323$$

Subject Stop Log Structure - B&M RR - Northampton Dike
Computation Counterfort Steel
Computed by CWBM Checked by Date 3-31-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528



Moment at intersection of wall and base equals approximately (see stability computations)

$$
\begin{aligned}
+95{,}600 \times 3.43 &= 327{,}000 \\
+102{,}400 \times 4.58 &= 471{,}000 \\
+143{,}300 \times 3.43 &= 493{,}000 \\
\Sigma &= 1{,}291{,}000 \\
-128{,}000 \times 1.92 &= 246{,}000 \\
 & 1{,}055{,}000
\end{aligned}
$$

Distributing this among the 3 counterforts

$$M = \frac{1{,}055{,}000}{3} = 352{,}000 \text{ ft\#}$$

Assume one half the load to be carried by the verticals and horizontals. Furnish sufficient steel in the top face to carry half the moment.

$$A_s = \frac{M}{8 f_s} = \frac{352{,}000}{8 \times 18{,}000} = 2.45 \square'' \text{ per counterfort} = 1.23 \square'' \text{ per face}$$

Use $1\frac{1}{8}$# bars, 2 per counterfort.

together with $5/8''\phi$ @ 12"cc, horizontally and vert.

all hooked into slabs.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Stoplog Structure - B&M RR - Northampton Dike
Computation Steel in Wall - Center Section
Computed by CWBM **Checked by** **Date** 3-31-39

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Assume that the horizontal load is carried to the counterforts by beam action.

At all depths beneath the railroad fill, the horizontal pressure equals

$$\omega = 8 \times 80 = 640\ \#/\square'$$

Assume the maximum moment $= \omega L^2/10$

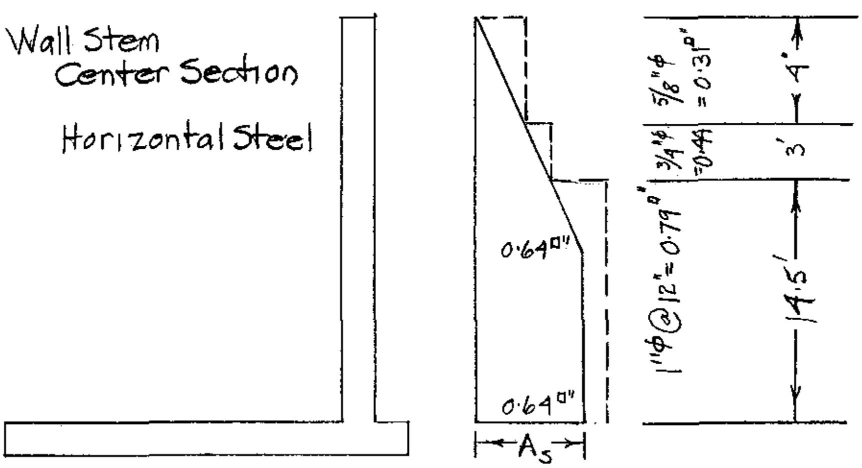
$$M = \frac{640 \times 13.5^2}{10} = 11{,}700\ ft\# = 140{,}000\ ''\#$$

$$A_s = M/f_s jd = 140{,}000/18{,}000 \times 0.88 \times 14 = 0.64\ \square''/ft$$

use 1" φ @ 12" cc

In the end section, there is only a negligible transverse load and it is entirely unnecessary to design for it, since temperature steel can be depended upon to carry it.

Wall Stem
Center Section
Horizontal Steel



Subject: Stop Log Structure - B&M RR - Northampton Dike
Computation: Heel Slab - Center Section
Computed by: CWBM Checked by: Date: 3-31-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Assume the slab between the counterforts to act as a partially restrained beam of maximum moment $wL^2/10$

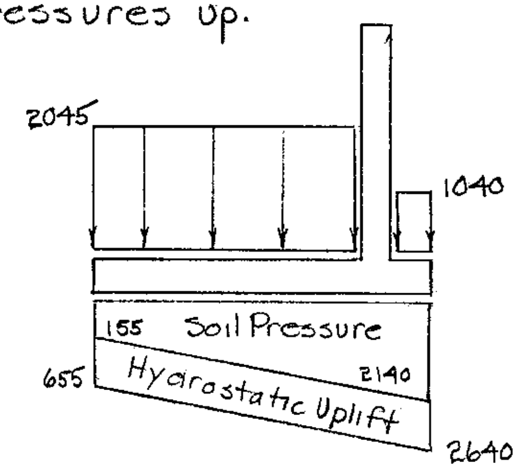
The design load is the difference between the weights down and the base pressures up.

Weight of soil = $14.5 \times 125 = 1820$
$1.5 \times 150 = \underline{225}$
2045 #/□'

$6.5 \times 125 = 815$
$1.5 \times 150 = \underline{225}$
1040 #/□'

Uplift = $8.0 \times 62.5 = 500$ #/□'

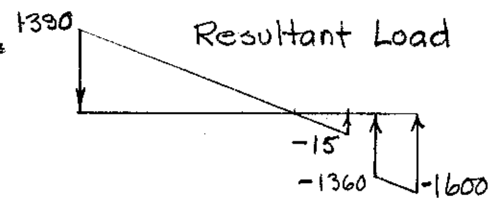
Soil bearing = 155 #/□' & 2140 #/□'



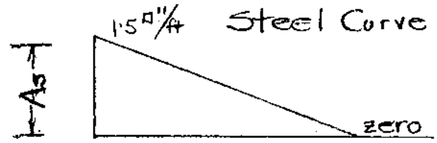
At dikeside toe

$$M = \frac{wL^2}{10} = \frac{1390 \times 13.5^2}{10} = 25,400^{ft\#} = 305,000^{''\#}$$

$$A_s = M/f_s jd = 305,000 / 18,000 \times 0.88 \times 13.5 = 1.43$$



At wall stem - M = zero
A_s = zero



For railroad side toe - (as a cantilever)

$$M = \frac{L^2}{6}(2w_1 + w_0) = \frac{1.5^2}{6}(2 \times 1525 + 1360) = 1660^{ft\#} = 19,800^{''\#}$$

$$A_s = M/f_s jd = 19800 / 18,000 \times 0.88 \times 13.5 = 0.08 \,□''/ft$$

Use 5/8" ⌀ @ 12" cc

Subject: StopLog Structure - B&M RR - Northampton Dike
Computation: Heel Slab - Outer Section
Computed by: CWBM   Checked by: Date: 3-31-39

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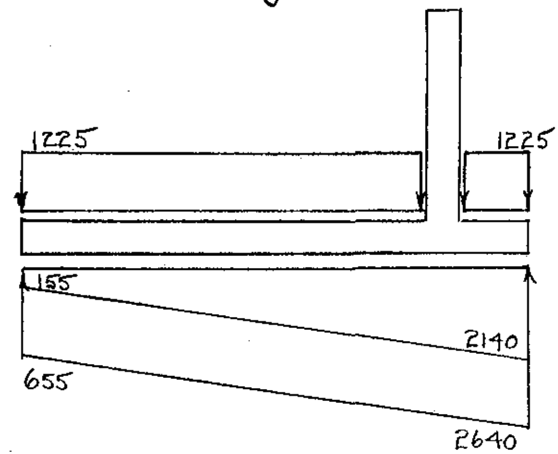
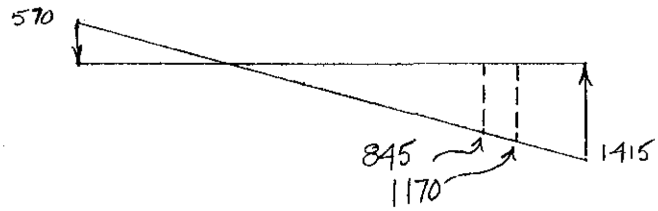
Assume the entire end region cantilevered from wall.

Earth = 8 × 125 = 1000#
Concr = 1.5×150 = 225
1225#/□'





Moment on dikeside =

$$\frac{L^2}{6}(2w_1+w_0) = \frac{8.56^2}{6}(2\times570-845) = 3600\ ^{ft\#} = 43{,}300\ ^{in\#}/ft$$

$$A_s = M/f_s jd = 43{,}300/18{,}000\times0.88\times13.5 = 0.21\ ^{\square''}/ft$$ - use 5/8"φ @ 12" cc

On railroad side

$$M = \frac{L^2}{6}(2w_1+w_0) = \frac{1.44^2}{6}(2\times1415+1170) = 1380\ ^{ft\#} = 16{,}600\ ^{in\#}/ft$$

$$A_s = M/f_s jd = 16{,}600/18{,}000\times0.88\times13.5 = 0.08\ ^{\square''}/ft$$ use 5/8"φ @ 12" cc

WAR DEPARTMENT
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Stop Log Structure - B&M RR - Northampton Dike
Computation Plan of Stressed Steel
Computed by CWB/BM **Checked by** ______ **Date** 3-31-39

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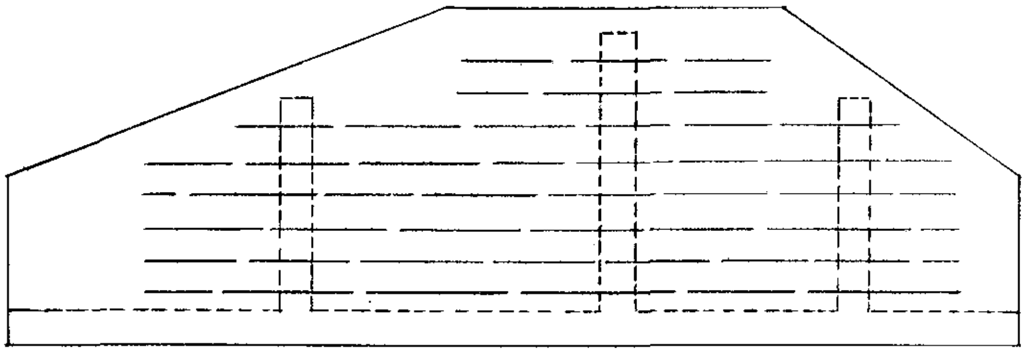
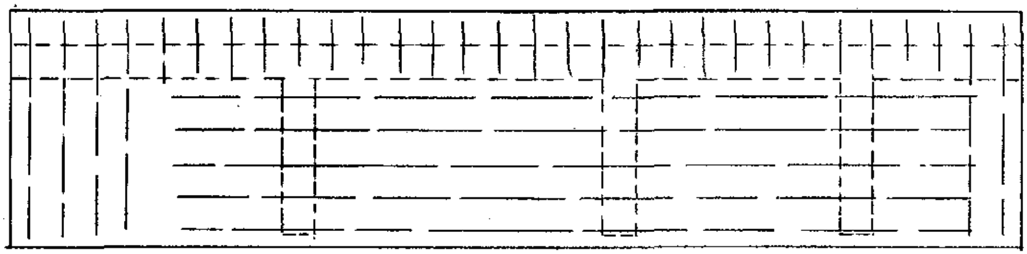


Elevation



Plan

For steel in wall see page
" " " base " "

The minimum temperature reinforcing of 5/8"φ bars spaced 12" on centers is to be used where no stressed steel is indicated.

Subject Stop Log Structure - B&M RR - Northampton Dike
Computation Stop Logs
Computed by CWPM Checked by Date 4-3-39
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Simple beam span = 15.5^{ft}
Maximum water head = 6.83^{ft} --- use $6.83 - 0.5 = 6.33'$

Bending Moment = $\frac{wL^2}{8} = \frac{6.33 \times 62.5 \times 15.5^2}{8} = 11{,}800^{ft\#} = 142{,}000^{''\#}$

Using $f = \frac{M}{S}$ $\quad 1750 = \frac{142{,}000^{''\#}}{\frac{12 \times d^2}{6}}$; $d^2 = \frac{142{,}000 \times 6}{12 \times 1750} = 40.5$

$d = 6.4''$

Next larger stock size timber is $7\frac{1}{2}''$ thick — nominal = 8"

use 6"×8" Select White Oak, S4S, creosoted.

Handling weight = $\frac{50^{\#} \times 5\frac{1}{2} \times 7\frac{1}{2} \times 15.5}{144} = 225^{\#}$ per log.

Check on longitudinal shear –

End shear = $\frac{wL}{2} = \frac{6.33 \times 62.5 \times 15.5}{2} = 3070^{\#}$

$v = \frac{3}{2} \times \frac{V}{A} = \frac{3}{2} \times \frac{3070}{12 \times 7.5} = 51^{\#}/\square''$ ------ max allow = $156^{\#}/\square''$

End bearing @ $265^{\#}/\square''$

$p = \frac{V}{A}$; $\quad 265 = \frac{3070}{12 \times t}$; $\quad t = \frac{3070}{12 \times 265} = 1''$ end bearing.

add to this 1" free play and ½" uncertainty.

Width of bearing surface = $1'' + 1'' + \frac{1}{2}''$ as minimum. = $2\frac{1}{2}''$

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Stop Log Structure - B&M RR - Northampton Dike

Computation Center Bracket

Computed by CW/BM **Checked by** **Date** 4-1-39

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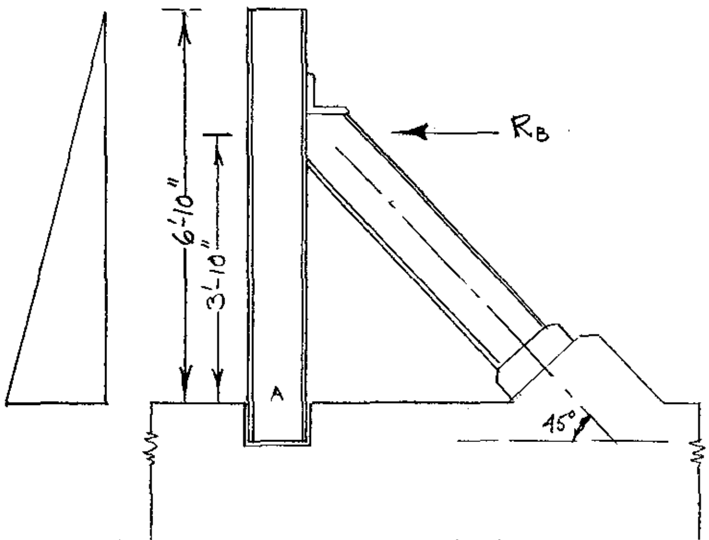


Assume the principal dimensions as shown

Assume pt A to have no moment.

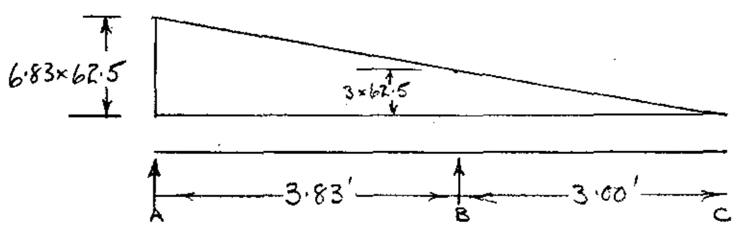
Moment of water $= \frac{wh^3}{6} \times L = \frac{62.5 \times 6.83^3 \times 15.5}{6} = 51{,}700^{ft\#}$

Horizontal Component of strut thrust

$R_B = \frac{M}{L} = 51{,}700 / 3.83 = 13{,}500^{\#}$

Strut thrust $= 13{,}500 \times \sqrt{2} = 19{,}100^{\#}$

Bending moment in vertical beam.

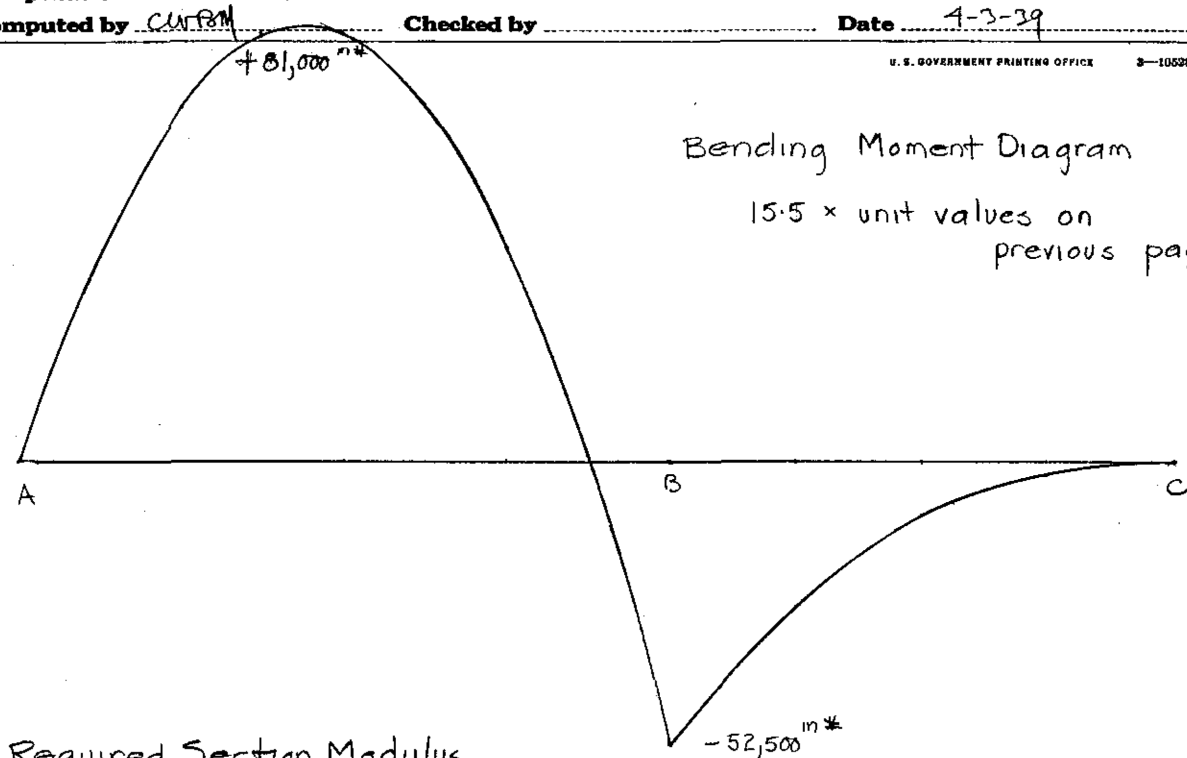


Cantilever moment $= \frac{wL^3}{6} = \frac{62.5 \times 3^3}{6} = 281^{ft\#} = 3{,}380^{in\#}/ft$

Simple beam moment$_{AB} = \frac{1}{8}\left(\frac{6.83+3}{2}\right) \times 62.5 \times 3.83^2 = 56.5^{ft\#} = 6800^{in\#}/ft$

" " " $_{BC} = \frac{1}{8}\left(\frac{3+0}{2}\right) \times 62.5 \times 3.00^2 = \quad = 1050^{in\#}/ft$

Subject Stop Log Structure - B&M RR - Northampton Dike
Computation Center Bracket
Computed by CWRM Checked by Date 4-3-39



Bending Moment Diagram

15.5 × unit values on previous page

Required Section Modulus

$$S = \frac{M}{f} = \frac{81,000^{in\#}}{18,000\ \#/\square''} = 4.5^{in^3}$$

Choice of beam - Vertical beam

The governing factors in this case are the dimensions of the logs to be used -

Required depth of section = depth of log + flange = 8" + =
" flange width = 2× bearing " " + web = 5" + =

Use a 10" beam (clear depth = $10'' - 2\times\frac{1}{2}'' = 9''$)
10" flange (bearing = $(10 - \frac{1}{2}) \div 2 = 4\frac{1}{2}''$.)

--- 10" CB 49#

Choice of beam - Inclined strut -

Length $= 3.83 \times \sqrt{2} = 5.4' = 65''$
Desireable (L/r) ratio = 80 $r = \frac{65}{80} = 0.81$
Try an 8" 18.4# -- r = 0.84 ; A = 5.34□"
Allowable $f = 18,000 / 1 + \frac{1}{18,000}(\frac{L}{r})^2 = 13,400\ \#/\square''$

Actual $f = \frac{19,100}{5.34} = 3,600\ \#/\square''$ ---- use 8" × 18.4# Am Std

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page A-15

Subject: Stop Log Structure – B&M RR – Northampton Dike

Computation: Anchor pins + Stop Log Hoist

Computed by: CWBM Checked by: ______ Date: 4-3-39

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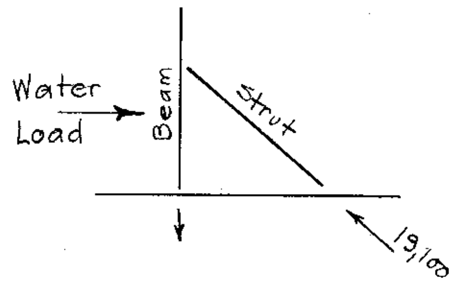
Check on uplift on barrier due to overturning



The downward pull on the beam must equal the vertical component of the strut thrust

$$19{,}100 \times \frac{\sqrt{2}}{2} = 13{,}500^{\#}$$

Use two pins through flanges of I beam –

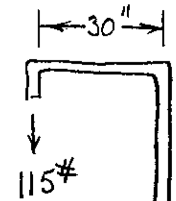
all. shear = P/A

$$12{,}000 = \left(\frac{13{,}500}{2}\right)/A \qquad A = 0.56^{\square''} \quad d = 7/8'' \text{ pin}$$

Design of Stop Log Hoist Frame

Assume one half of one log as load –

$$225/2 = 115^{\#}$$



Bending moment = $115 \times 30 = 3450$ in#

Try a $2\frac{1}{2}''$ WI pipe – diameters = 2.875 and 2.469

$$\text{Area} = \pi \times 2.67 \times \left(\frac{\overset{.203}{2.875 - 2.469}}{2}\right) = 1.70^{\square''}$$

$$I = 0.049\,(d^4 - d^4) = 0.049 \times 31.1 = 1.52 \text{ in}^4$$

$$f = \frac{P}{A} + \frac{Mc}{I} = \frac{115}{1.7} + \frac{3450 \times 1.44}{1.5} = 67 + 3300 = 3370\ ^{\#}/_{\square''}$$

APPENDIX "A"

SECTION "B"

STRUCTURAL COMPUTATIONS FOR HIGHWAY STOP-LOG STRUCTURE AT ROUTE 5, NORTHAMPTON, MASS.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

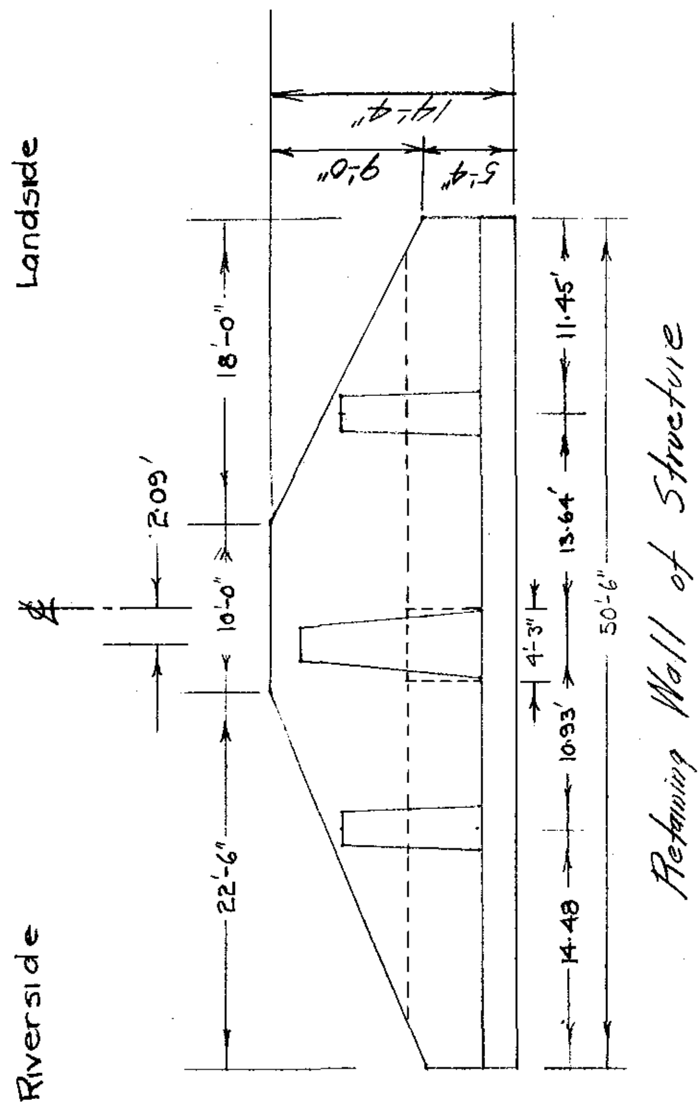
Page B-1

Subject Northampton - Stop Log - Highway #5

Computation Dimensions

Computed by CWBM Checked by ______ Date 2-23-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

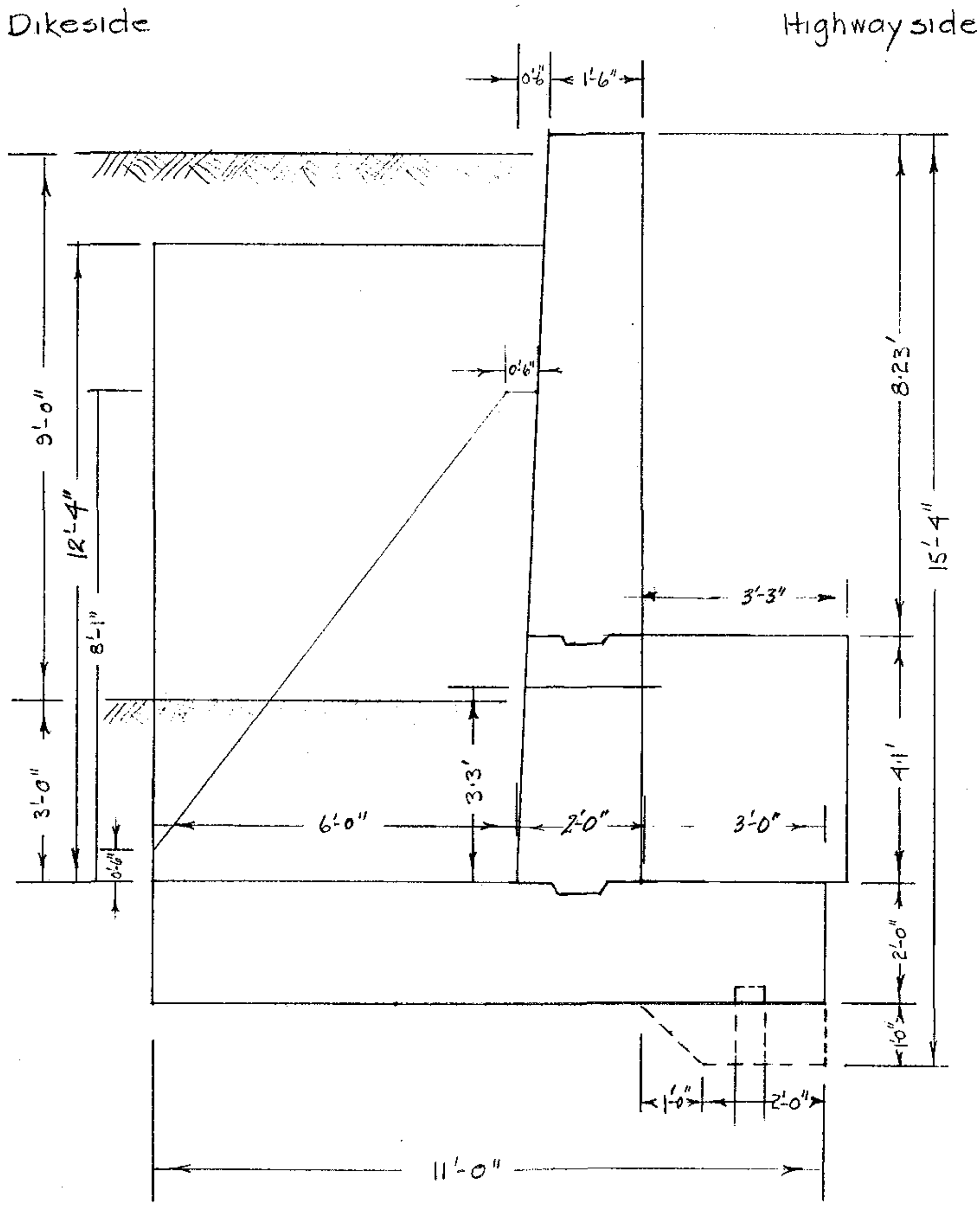
Page B-2

Subject Northampton - StopLog - Highway #5

Computation Dimensions

Computed by CWBM **Checked by** **Date** 2-23-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528



B-2.

Subject Northampton Stop Log - Highway #5
Computation Loadings - Case I - River Suddenly Receded.
Computed by CWBM Checked by Date 2-23-39

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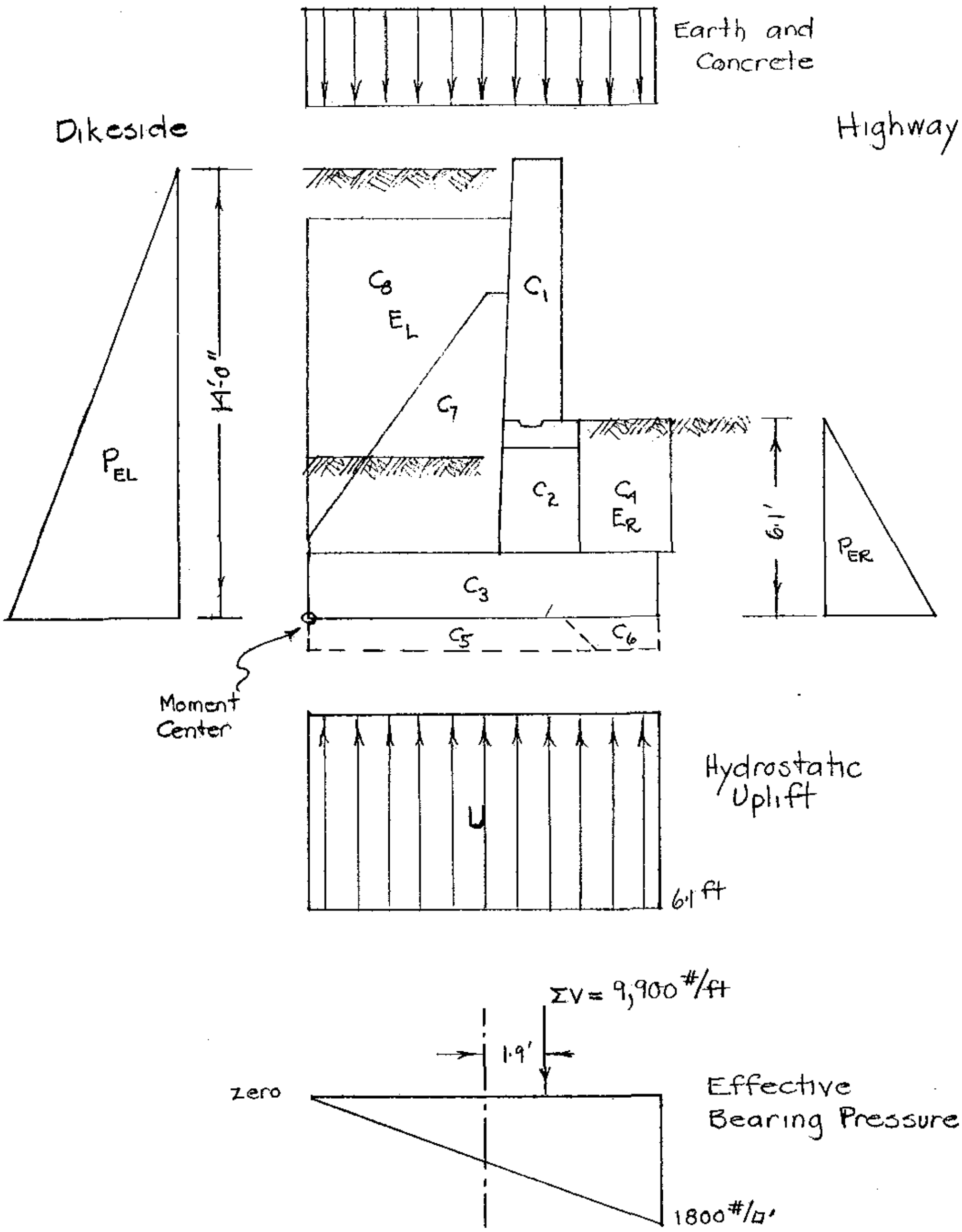


WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Northampton - Stop Log - Highway #5
Computation Stability - entire structure - see pp 3 - Case I
Computed by CWBM **Checked by** JJ **Date** 2-23-39

Since the difference in the unit weights of concrete and earth is small, the bothersome batters of the wall have been neglected. The error due to this is negligible.

Load	Dimensions ft-# Height × Width × L	Wt	Verticals - lbs + ↓	Verticals - lbs − ↑	Horizontals - lbs + →	Horizontals - lbs − ←	Lever ft	Moments ft-lbs + ↷	Moments ft-lbs − ↶
C_1	8.23×1.5×46	150	85,200				7.25	617,700	
	½×8.23×1.5×18	150		16,700			7.25		121,100
	½×8.23×1.5×22.5	150		20,900			7.25		151,500
C_2	4.1×2.5×50.5	150	77,600				7.25	562,600	
C_3	2.0×11.0×50.5	150	166,700				5.5	916,900	
C_4	4.1×2.9×4.25	*25	1,260				9.88	12,400	
C_5	2×1.0×8.5×3.0	150	7,650				4.25	32,500	
C_6	1.0×2.5×50.5	150	19,000				9.75	182,500	
C_7	8.1×6.0×2.3	*25	2,800				4.0	11,200	
	½×7.6×5.8×2.1	*25		1,150			2.0		2,300
C_8	10.5×6.25×2.5	*25	4,100				3.1	12,700	
E_L	7.90×6.5×46	125	295,300				3.25	959,700	
	½×7.90×6.5×18	125		57,800			3.25		187,900
	½×7.9×6.5×22.5	125		72,200			3.25		234,700
	4.1×6.0×50.5	125	155,300				3.0	465,900	
E_R	4.1×2.5×50.5	125	64,700				9.75	630,800	
P_{EL}	½×15.0×15.0×10	80			90000		4.00	360 000	
	$5.3^2 \times \frac{1+n+n^2}{6} \times 18$	80			82 300		3.87	318 500	
	$5.3^2 \times \frac{1+n+n^2}{6} \times 22.5$	80			100 000		3.87	387 000	
P_{ER}	½×6.1×6.1×50.5	80				75,100	1.36		102,100
U	6.1×11.0×50.5	62.5		211,800			5.5		1,164,900
Σ	Arithm		879 610	380,550	272,300	75,100		5,470,400	1 964 500
	Algebraic		ΣV_S = 499,060		ΣH_A = 197 200			ΣM 3,505,900	
F	0.45×499,060					224,700	zero		
Σ			ΣV_B = 499,060		ΣH_B = zero			ΣM_B = 3,505 900	
e	$\frac{3,505.9}{499.06}$ = 7.03								
ε	$\frac{11}{2}$ - 7.03 =	1.53							
p	$\frac{499,060}{11\times50.5}\left(1\pm\frac{6\times1.53}{11}\right)$	=	898 × 1.83 = 1644 #/□'		ε'	898 × .17 = 153 #/□'			B-4

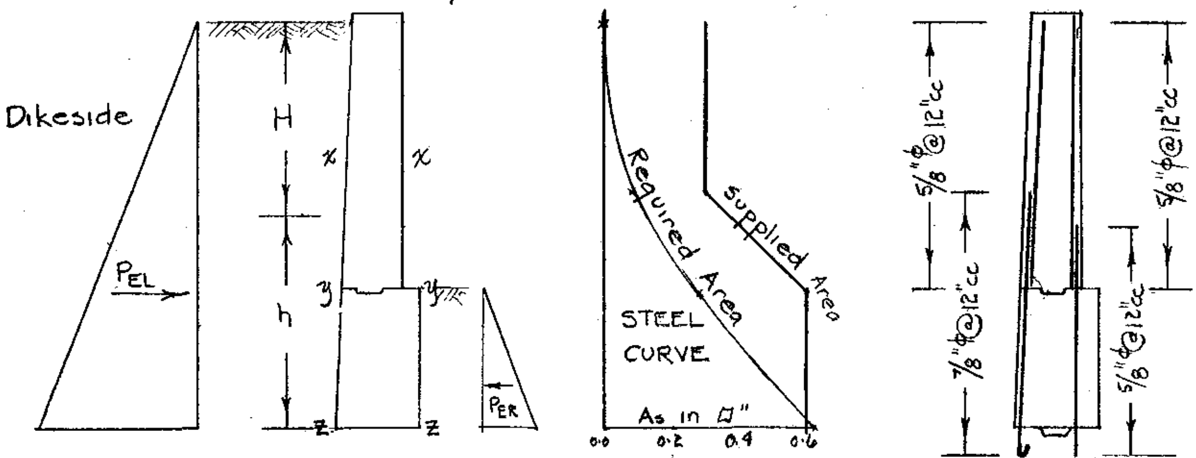
(* represents the excess over the displaced weight)

$n = \frac{15}{5.3} = 2.83$
$M_1 = 40.3$
$H_h = 13.2$
$e_h = 0.73$

Subject Northampton – Stop Log – Highway #5
Computation Design of Wall Steel – Central Section
Computed by CWBM **Checked by** **Date** 2-24-39

U. S. GOVERNMENT PRINTING OFFICE 8—10538

Case I – Cantilever (Simple) – Dikeside Face



Bend. Moment at	h	Force	Dimensions	Wt	Forces – lbs + →	Forces – lbs − ←	Lever Arm ft	Moment – ft lbs + ↷	Moment – ft lbs − ↶
x-x	7	P_{EL}	$\frac{1}{2}\times5\times5$	80	1000		1.67	1,670	
y-y	4.1	P_{EL}	$\frac{1}{2}\times7.9\times7.9$	80	2500		2.63	6,600	
z-z	0	P_{EL}	$\frac{1}{2}\times12\times12$	80	5,760		4.0	23,000	
		P_{ER}	$\frac{1}{2}\times4.1\times4.1$	80		675	1.37		925
					Σ=5,085			Σ=22,075	

$$\text{Balanced "d"} = \sqrt{\frac{M''^{\#}}{Kb}} = \sqrt{\frac{M'^{\#}\times12}{123\times12}} = \sqrt{\frac{M'^{\#}}{123}} \qquad (f_s=18{,}000;\ f_c=800;\ n=12)$$

$$A_s = \frac{M''^{\#}}{f_s jd} = \frac{M'^{\#}\times12}{18{,}000\times0.88\times d} = \frac{12}{18{,}000\times0.88}\times\frac{M'^{\#}}{d} \qquad bjd = 12\times0.88\times d$$

Section	Theoret "d" √	d"	Supplied d $d_o-4"$	d"	Steel Area M/d ×	A_s □"	V #	$v = V/bjd$ #/□"	Bond Bar	$u = V/\Sigma_0 jd$ #/□"
x-x	1670/123	4	20-4	16	1670/16	0.08	1000	6	5/8"φ	36
y-y	6600/123	7.5	22-4	18	6600/18	0.28	2500	13	7/8"φ	58
z-z	22,075/123	13.2	30-4	20	22,075/26	0.67	5085	18	1"φ	78

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

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Subject Northampton - Stop Log - Highway #5

Computation Design of Wall Steel - Outer Section - Wall Height 9'

Computed by CWBM **Checked by** JGG **Date** 2-24-39

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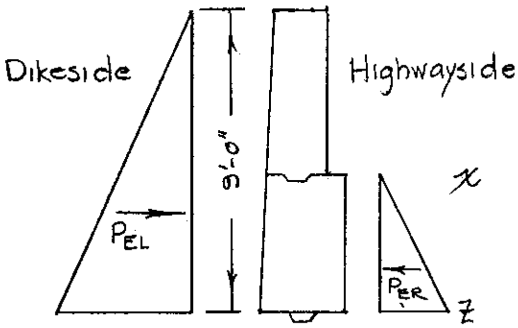
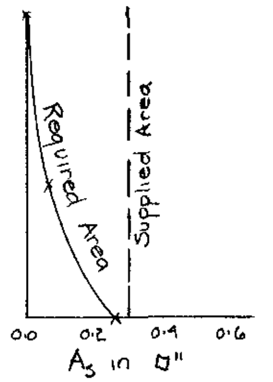
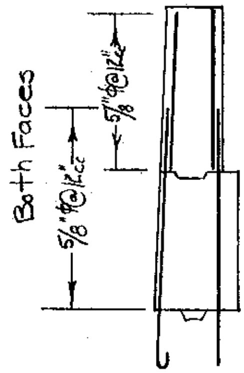






Bend. Mom Section	h	Symb.	Force Dimensions	lbs Wt	Force lbs + →	Force lbs − ←	Lever Arm	Moment ft lbs +	Moment ft lbs −
x-x	4.1	P_{EL}	$\frac{1}{2}\times4.9\times4.9$	80	960		1.63	1560	
z-z	0.0	P_{EL}	$\frac{1}{2}\times9.0\times9.0$	80	3240		3.0	9750	
		P_{EE}	$\frac{1}{2}\times4.1\times4.1$	80		670	1.37		920
		Σ_{zz}			2570			8830	

$$\text{Balanced "d"} = \sqrt{\frac{M''\#}{Kb}} = \sqrt{\frac{M'\#\times12}{123\times12}} = \sqrt{\frac{M'}{123}}$$

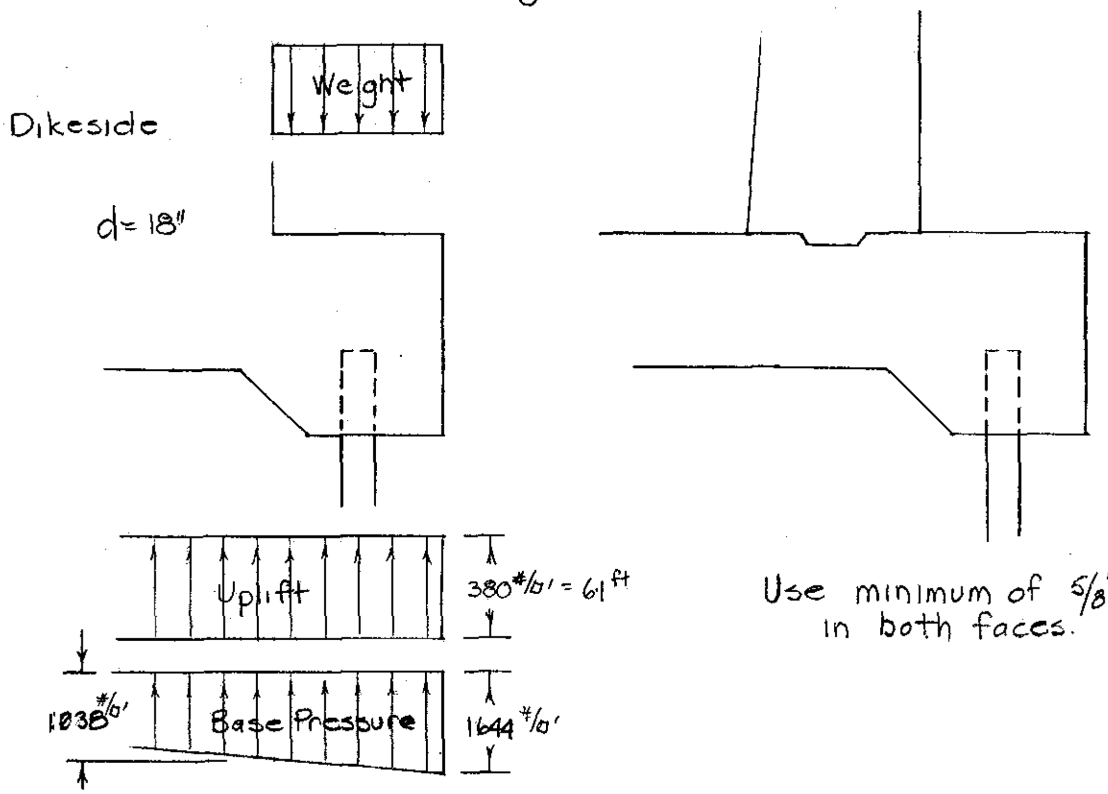
$(f_s = 18{,}000;\ f_c = 800;\ n = 12)$

$$A_s = \frac{M''\#}{f_s jd} = \frac{M'\#\times12}{18{,}000\times0.88\times d} = \frac{12}{18{,}000\times0.88}\times\frac{M}{d}$$

$bjd = 12\times0.88\times d$

Section	Theoret. "d" $\sqrt{\ }$	Theoret. "d" d"	Supplied "d" d_o-4"	Supplied "d" d	Steel Area M/d ×	Steel Area A_s □"	V #	$v = V/bjd$ #/□"	Bond Bar	Bond $u = V/\Sigma_o jd$ #/□"
x-x	1560/123	4	22-4	18	1560/18	0.06	960	5	5/8φ	31
z-z	8830/123	8.6	30-4	26	8830/26	0.26	2570	10	5/8φ	58

Subject Northampton - Stop Log - Highway #5
Computation Base Steel - Highway Side
Computed by CWBM Checked by JJD Date 2-24-39



Use minimum of 5/8"φ@12"cc in both faces.

Section			Forces Dimensions	Wt	Forces - lbs + ↓	Forces - lbs − ↑	Lever Arm	Moments - ft lbs + ↷	Moments - ft lbs − ↶
		E	4.1 × 2.5	125	1280		1.25	1600	
		C	3.0 × 2.5	125	940		1.25	1180	
		U	6.1 × 2.5	62.5		950	1.25		1190
		b_1	1238 × 2.5			3095	1.25		3870
		b_2	½ × 406 × 2.5			500	1.67		840
Throat		Σ			2220	4540		2780	5800

ΣV = 2320# ↑ ΣM = 3020 ↶

Bal. "d" $= \sqrt{\frac{M}{Kb}} = \sqrt{\frac{3020 \times 12}{123 \times 12}} = 4.95$ Supplied d = 18"

$A_s = \frac{M}{f_s jd} = \frac{3020 \times 12}{18{,}000 \times 0.88 \times 18} = 0.13\square''$ Use minimum of 5/8"φ@12"cc

$V = 2730\#$; $v = \frac{V}{bjd} = \frac{2320}{12 \times .88 \times 18} = 12\#/\square''$ $u = \frac{V}{\Sigma jd} = \frac{2320}{1.96 \times 0.88 \times 18} = 74\#/\square''$

Embedment $= \frac{f_s A_s}{u \Sigma} = \frac{18{,}000 \times 0.3}{150 \times 1.96} = 19''$

WAR DEPARTMENT

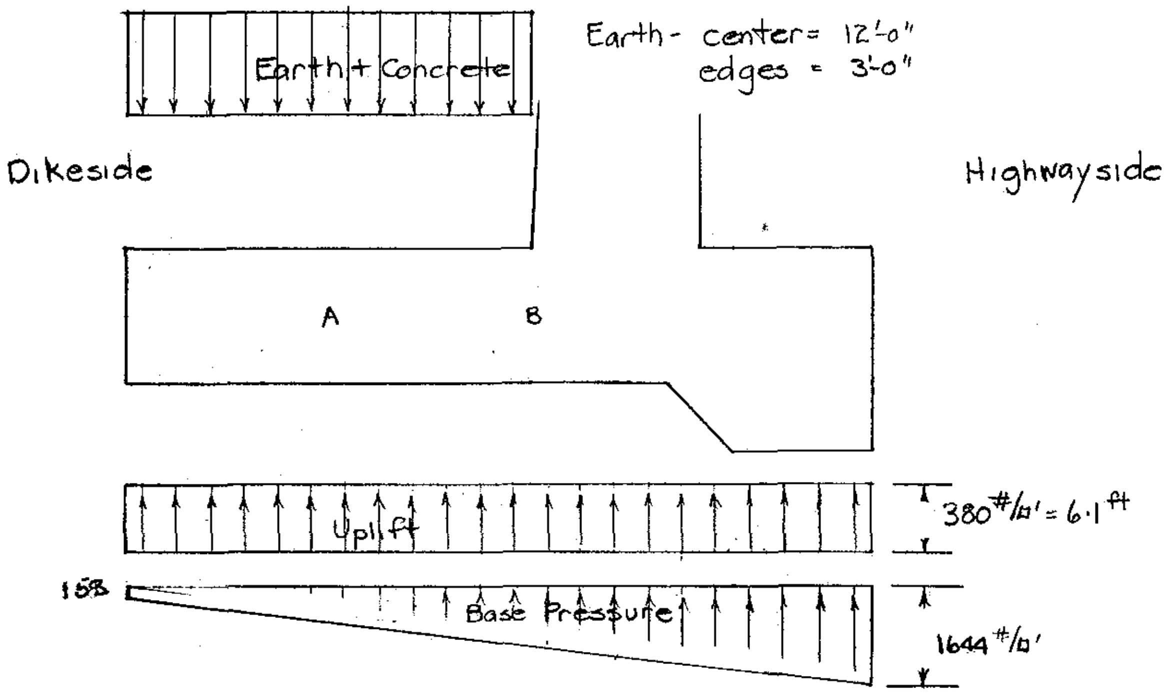
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Northampton - Stop Log - Highway #5

Computation Base Slab - Steel in Dikeside - /

Computed by CWBM **Checked by** JPG **Date** 2-24-39

U. S. GOVERNMENT PRINTING OFFICE 8—10838



	Forces			Forces - lbs		Lever Arm	Moments - ft lbs.	
	Symb.	Dimensions	Wt	+ ↓	− ↑		+	−
Moments-A	C	2.0×3.0	150	900		1.5		1350
	U	6.1×3.0	62.5		1140	1.5	1720	
	B.P	½×408×3.0			610	1.0	610	
	"	153×3			460	1.5	690	
at center	E_c	12.0×3.0	125	4500		1.5		6750
	Σ_c			3190#				5080'#
at outside	E_o	3.0×3.0	125	1125		1.5		1690
	Σ_o			185				20'#
Moments B	C	2.0×6.0	150	1800		3.0		5400
	U	6.1×6.0	62.5		2290	3.0	6860	
	BP	½×810×6.0			2430	2.0	4860	
		153×3			460	1.5	690	
at center	E_c	12.0×6.0	125	9000		3.0		27,000
	Σ_c			5620				20000'#
at outside	E_o	3.0×6.0	125	2250		3.0		6,750
	Σ_o				1130		260	

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Northampton - Stop Log - Highway #5

Computation Base Slab - Steel in Dikeside

Computed by CWBM **Checked by** JJO Jr **Date** 2-25-39

Balanced "d" $= \sqrt{\frac{M}{Kb}} = \sqrt{\frac{M^{\prime\#}}{123}}$ $f_s = 18{,}000$; $f_c = 800$; $n = 12$

$A_s = \frac{M}{f_s j d} = \frac{M^{\prime\#} \times 12}{18{,}000 \times 0.88 \times d} = \frac{12}{18{,}000 \times 0.88} \times \frac{M^{\prime\#}}{d}$ $bjd = 12 \times 0.88 \times 19.5 = 206$

	Theoret "d"		Supplied "d"		Steel Area		V	v =	Bond	
	$\sqrt{\ }$	d"	$d_o - 4.5$"	d"	M/d ×	A_s □"		V/bjd	Bar	u = V/Σ o j d
							#	#/□"	@12"cc	#/□"
A-center	5080/123	6.8	24-4.5	19.5	5080/19.5	0.19	3190 ↓	17	5/8" φ	95
B-center	20,000/123	12.6	24-4.5	19.5	20000/19.5	0.77	5080 ↓	27	1" φ	94
A-outer	20/123	–	24-4.5	19.5	20/19.5	–	1.85 ↓	–	5/8" φ	–
B-outer	260/123	–	24-4.5	19.5	260/19.5	–	1130 ↑	–	5/8" φ	–

Since the earth load varies linearly along the wall, the moment at "B" will also vary linearly